S. A. E. JOURNAL

Published by the Society of Automotive Engineers, Inc., *29 W. 39th St., New York*

Issued monthly, $1 a number, $10 a year; foreign $12 a year; to members, 50 cents a number, $5 a year. Entered as second-class matter, Jan. 14, 1928, at the post office at New York, N. Y., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of Oct. 3, 1917, authorized on Jan. 14, 1928.

W. G. Wall, *President* Coker F. Clarkson, *Secretary* C. B. Whittelsey, *Treasurer*

Vol. XXIV January, 1929 No. 1

CONTENTS

The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.

S. A. E. JOURNAL

Vol. XXIV January, 1929 No. 1

Another Aeronautic Milestone Passed

Joint Meeting in Chicago with Aeronautical Chamber of Commerce Marked by Excellent Papers and Lively Interest

DEC. 3 to 8 was notably Airplane Week in Chicago, most obviously at the Coliseum and the Hotel Stevens. Coincident with the International Aeronautical Exposition, which completely filled the main floor and galleries of the Coliseum, the Greer Building and the First Regiment Armory, the Aeronautical Chamber of Commerce held meetings throughout the week in the Hotel Stevens and the Society held its second Aeronautic Meeting of the present season jointly with the Chamber on Wednesday and Thursday. The American Petroleum Institute held its ninth Annual meeting also at the Stevens on Tuesday, Wednesday and Thursday, with a resulting traffic jam in the lobby that would have baffled the efforts of a squad of traffic officers.

Success of the Society's meeting was due largely to the cooperation of the Aeronautical Chamber of Commerce and to the attraction of the Aircraft Show for representative members of the aeronautic industry throughout the Country and even in foreign countries.

Attendance Representative of Industry

Attendance at the technical sessions was exceptional and indicated the leading part the Society is now taking in the aeronautic industry. This position is warranted by the fact that 5 per cent of the members of the Society are connected with companies building aircraft, as compared with 13 per cent connected with passenger-car companies, 9 per cent with motor-truck manufacturers, 3 per cent with motorcoach builders, 2 per cent with tractor companies and 1 per cent with concerns building motorboats. Moreover, of the 40 per cent of members who are connected with companies manufacturing parts, accessories and materials for automotive vehicles of all kinds, probably as many, if not more, are interested in aeronautics as in any other branch.

The aggregate attendance was 360 and included recognized leaders in aircraft design and production from the Atlantic to the Pacific. Even the final session on Thursday night drew the comment from Assistant Secretary of the Navy Warner that he was highly

Several Prominent Men Among the 330 Attending the Technical Sessions

(From Left to Right) J. W. Tierney, Chairman of the Chicago Section, Who Was Host at the Get-Together Dinner; William B. Stout, Nominee for Second Vice-President for Aeronautics for 1929; Capt. T. G. Hetherington, British Attaché, and Capt. Francis Thomas Courtney

Meetings Calendar

1929 SUN.	MON.	JANUARY TUES.	WED.	THUR.	FRID.	1929 SAT.
		1	2	3	4	5
6	7 METROPOLITAN	8 CHICAGO AVIATION DIVISION	9	10 ANNUAL DINNER	11	12
13	14	15 ANNUAL MEETING	16 NEW ENGLAND	17	18 SOUTHERN CALIFORNIA	19
20	21 WASHINGTON	22	23	24	25	26
27	28	29	30	31		

Annual Dinner

Jan. 10, 1929, The Waldorf-Astoria, New York City

Annual Meeting

Jan. 15 to 18, 1929, Book-Cadillac Hotel, Detroit

Chicago Section Aviation Division Meeting—Jan. 8, 1929

Aviation Fuels—D. P. Barnard, Standard Oil Co. of Indiana.

Radial Aircraft-Engine Maintenance—R. Moffat, Wright Aeronautical Corp.

Metropolitan Section Show Dinner—Jan. 7, 1929

A Review of the 1929 Show Cars: Bodies—Francis D. Willoughby, Willoughby Co.; Chassis—Austin M. Wolf, Newark; Engines—Harry L. Horning, Waukesha Motor Co.

What 500 Motorists Think of Their Present Cars and What Changes They Want in Their New Cars

New England Section Meeting—Jan. 16, 1929

Service Meeting—Special Service Equipment and Operations—Practical Demonstrations and Pictures. Speakers will be several service managers of greater Boston

Northwest Section Meeting—Jan. 19, 1929

Bergonian Hotel, Seattle

Southern California Section Meeting—Jan. 18, 1929

Joint Session with Western Metal Congress

Manufacture and Heat-Treatment of Automobile Leaf-Springs—J. B. Rauen, U. S. Spring Co.

Production of Nickel-Steel Castings by Electric-Furnace Method—E. Favary, Moreland Truck Co.

Aluminum as Applied to the Automobile and Airplane Industries—Dr. Zay Jeffries, Aluminum Co. of America

Some Phases of Aircraft Construction

Metallurgical and Heat-Treating Problems in Motor-Car Manufacture—J. M. Watson, Hupp Motor Car Co.

Washington Section Meeting—Jan. 21, 1929

Fuel and Lubricants

gratified to see so large an attendance at a session devoted exclusively to lighter-than-air craft.

The informal Get-Together Dinner on Thursday evening, which was attended by 171, admirably fulfilled the purpose indicated by its title and reflected much credit upon the Chicago Section, which acted as host.

Technical Program Excellent

Excellence of the technical program, as regards variety and quality of the ten papers presented, was most creditable to the authors and speakers and to the Aeronautic Meeting Committee consisting of Glenn L. Martin, Chairman; Edward P. Warner, E. S. Land, L. M. Woolson, and E. D. Osborn. So good were all of the papers that it is difficult to single out those of superior merit, although on the basis of interest shown special mention may be made of those by L. M. Woolson, on Diesel engines; S. D. Heron, on air-cooled in-line engines; that presented by W. S. Herron on passenger-transport operation; the one by E. P. Lott, criticising present commercial airplanes constructively; and those by Dr. Karl Arnstein, dealing with design of lighter-than-air craft, and by Lieut-Com. Charles E. Rosendahl, with mooring masts and landing-trucks for them.

Highlights of the addresses and the discussion on them, of the joint standardization meeting, the dinner and the areonautical show are given in the following news reports. Most of the papers will be published in full in The Journal in successive issues as promptly as circumstances permit, the exceptional demand for preprints having indicated the desire of members who were unable to attend the meeting to study the papers.

Engines Get a Good Hearing

Non-Radial Air-Cooled and Diesel Types Advocated and Engine Maintenance Described

KEEN interest in the engine problem was made very evident at the first session of the meeting on Wednesday forenoon, Dec. 5, which was attended by 260 members and guests who filled every available chair in the inadequate parlor and stood throughout the session in knots at the doors of the anteroom. Each of the three papers presented held interest for the intent audience and there was much discussion on them, most of all that by Capt. L. M. Woolson, on Diesel Engines for Aircraft.

The meeting was opened by the Hon. Edward P. Warner with a welcome to the members and guests of the Society to this, the second aeronautic meeting held by the Society this season. E. T. Jones then took the chair and presided over the remainder of the session. With no long preliminaries, Mr. Jones called upon S. D. Heron, of the Materiel Division of the Army Air Corps, Wright Field, to present the first paper, Non-Radial Air-Cooled Engines.

Advantages of In-Line Engines

Although the trend of late has been almost altogether toward the radial type of air-cooled engine, Mr. Heron said the time seems to be ripe for discussing the pros and cons of the in-line type. The air-cooled V-type Liberty engine built at McCook Field in 1924 was the first modern in-line engine, he said, and it served to show what can be done with a compact high-powered line engine. In England, the Cirrus engine, of the line type, has come into wide use and has given remarkable performance in Moth and Avian airplanes.

Without disparagement of the radial engine, Mr. Heron pointed out the possibilities of the in-line air-cooled engine and dealt with some of the problems its development presents. A very considerable reduction of frontal area and of obstruction of visibility by the pilot are two of the important advantages mentioned. Several types of cowling were shown in slides, and the de Havilland Tiger Moth was referred to as an example worthy of study by those who are installing in-line engines. With an engine output of 130 b-hp., this racing plane attained a speed of nearly 200 m.p.h., which shows the possibilities of speed with the in-line engine.

Cowling should be arranged so that the air enters the cowl with the minimum disturbance and interference, not overlooking the spiral rotation of the slipstream. Mr. Heron showed that velocity of the cooling air in the fin cells is not limited to the velocity of the airstream, and in high-speed airplanes the parasitic drag can be greatly reduced by cowling.

Visibility with Inverted Engine

Inverting the V-type engine gives the pilot much better visibility than with either the radial or the upright V engine and also simplifies the arrangement of the exhaust; the piston lubrication is more certain during the warming-up period, and enclosed and lubricated valve-gear can be given a very large oil supply. Inlet manifolding on the inverted engine presents a rather difficult problem, however.

Experience indicates that adequate cooling can be obtained, according to the speaker, if the space between cylinder bores is equal to 35 or 40 per cent of the bore diameter. That the advantages of six cylinders over four can be obtained with no great additional engine length was shown by comparing a four and a six-cylinder engine each of 400 cu. in. capacity and 6 in. stroke. The extreme lengths over the cylinders are respectively 26 and 31½ in.

After taking up various other details, the author concluded with considerations of the in-line engine as a production manufacturing design.

Engine Maintenance

Considerable discussion on various operating problems was elicited by a paper on Maintenance of Air-Cooled Engines in Commercial Operation, which was prepared by L. S. Hobbs, of the Pratt & Whitney Aircraft Co., and Edward Hubbard, of the Boeing Airplane Co. In the absence of both of the authors, this was read by A. V. D. Willgoos. Solution of the problem of engine maintenance for economical commercial operation lies, according to the authors, in the proper determination of the fuel and oil to be used, operating conditions of the engine as far as these are controllable by the pilot or the equipment, special equipment to meet special conditions, routine checking and adjustments, period of operation before overhaul and kind of overhaul, allowable limits of wear of parts before replacement, replacement parts carried in stock, and the stage in the life of an engine at which it should be scrapped rather than rebuilt with new parts.

One of the most vexing of the operator's problems is the determining of the fuel to be used. A difference in cost of only a few cents per gallon amounts to a considerable sum yearly when fuel is used at a rate of 1000 gal. per day or more, but as against this is the possible cost of damage resulting from use of an inferior fuel. Operators suffer from the engine manufacturers' lack of knowledge of what actually occurs in the engine cylinders and from the fuel refiners' lack of a common standard for measuring the antiknock quality of fuel. Even if such a standard were available, there is no certitude that detonation is the sole cause of trouble. The operator's only safe course is to use, regardless of cost, the fuel that experience has shown to be best. When California-base gasolines have been used, no forced landings resulting from a burned piston have been experienced in the Boeing Air Transport operations, and no case of burned piston in

At the Powerplant Session There Was Not Even Sufficient Standing Room Inside

an engine using such fuel has come under the observation of the authors.

Choice of a suitable lubricating oil is more easily made than that of the fuel, as it can be well specified on paper. The best oil is the cheapest in over-all operating cost, but the oil that costs the most per gallon is not necessarily the best. Particular attention should be paid to viscosity and freedom from carbon, and the oil should have high flash and fire-points and a low pour-test. It seems desirable, from the authors' experience, to use in air-cooled engines an oil of higher viscosity in summer than in winter.

Temperature Control Important

Control of the temperature of the engine, especially the cylinders, and of the intake-air are problems of the greatest importance and have a bearing on the cost of maintenance. The former must be controlled by cowling, which should conform somewhat to the shape of the fuselage or the nacelle. The most satisfactory installation at present consists of a fairly large nose cowling having adjustable shutters. It has been necessary in some cases to use oil-coolers, and these have been combined with the cowling so that the shutters and the oil-coolers are interconnected and controlled simultaneously. Experience has proved conclusively that all controlling must be effected from the cockpit.

Control of the temperature of air entering the carbureter and of mixture entering the cylinders presents a difficult problem that is aggravated by the large volume of air to be heated and the small space available. The hot-spot method of heating the mixture after it leaves the carbureter does not care for the most serious difficulty encountered—that of ice formation in the carbureter.

If dust is prevalent on landing-fields, a suitable air-cleaner and an oil-filter probably would be of great benefit in keeping abrasive material from the wearing parts of the engine.

In the Boeing operations, the airplanes are inspected at the terminal after each flight and the inspection record is shown to the next pilot.

As a result of test overhauls made after running periods of 150, 200 and 300 hr. and careful checking of man-hours required and replacements made, the conclusion was reached that the Boeing Air Transport would realize greatest economy if the engines were overhauled after each 150 hr. Experience indicates that a top overhaul is impracticable, as the man-hours required to give the engine a top overhaul in the plane are nearly as many as to give it a major overhaul in the shop, where the men can work much more efficiently. Moreover, by removing the engine and installing another, the expensive airplane can be maintained in service during the engine-overhaul period.

For 50 engines it has been necessary to carry in stock spare parts in proportions of 3 per cent for major parts and 10 per cent for minor parts, the value of such stock amounting to only about 5 per cent of the total value of the engine equipment.

Ultimate life of the Wasp and Hornet engines on the Boeing line has not been determined, as the average number of hours of flying is only about 1000. Experience is teaching the economy of reserve power in commercial operation, as it reduces the percentage of full power required for normal cruising and provides extra power for use in emergency, thus adding to safety, lengthening time between overhauls and reducing the rate of wear on moving parts.

In discussion on the Hobbs and Hubbard paper, Chairman Jones mentioned that good engine-maintenance is one of the operator's main problems, one of the fundamental requirements being experienced, skilled and careful all-round mechanics. Whereas engines formerly gave most trouble, it is doubtful if, with proper overhauling at suitable intervals, they now give much more trouble than the accessories of the airplane. Dr. S. A. Moss pointed out that not long ago 50 hr. was regarded as a long time between overhauls of an airplane engine, and does not doubt that the period of 150 hr., reported in this paper, will be extended to 500 hr. Chairman Jones said he thinks that the difference in overhaul periods is much less striking when both engines are put on a mileage basis. Secretary Warner reminded the audience that the average automobile engine is operated most of the time at only a small percentage of its power, whereas the aircraft engine that is now doing the equivalent of 30,000 to 40,000 miles compares with an engine driving a high-powered car at 60 to 70 m.p.h.

Fuel Problem Approaching Solution

Referring to fuel, Secretary Warner said that the importance of low weight and low frontal area is so great that we can well afford to pay a premium for high-test or doped gasoline and to go to the trouble of making sure that fuel of the best quality will be universally available at all fields. Engine designers are willing to go to the limit in designing engines to take advantage of fuel of the highest quality as soon as they are assured that the operators are willing to pay for the fuel and will take the trouble to get it. One way in which operators can be of great assistance to engine manufacturers, said Mr. Jones, is by getting together and making a concerted demand for fuels of fairly definite grades, particularly respecting antiknock property. The greatest possible service that could be rendered in respect to fuel, asserted Secretary Warner, would be for the Fuel Specification Board, the Society, the American Petroleum Institute or a joint committee of all interested parties to agree on one specification for a Class-A fuel materially higher in grade than domestic aviation gasoline, so that operators will have the option of saying that they are going to operate on Grade-A or Grade-B fuel instead of having to specify a certain trade-marked fuel the characteristics of which may be changed within a year.

Dr. Dickinson, of the Bureau of Standards, stated that a joint committee of the petroleum and automotive industries, of which T. A. Boyd is Chairman, has been working on the project of establishing a practical, workable, uniform standard for the specification and the determination of antiknock characteristics of fuel. It has made gratifying progress which indicates that within a few months the different laboratories may be able to agree upon a universal method of making this test. This probably will be based on the heptane-octane content, which seems to be the best standard.

John H. Geisse, of the Naval Aircraft Factory, suggested that the en-

gine manufacturer sell the engine complete with the best cowling he can develop that will be good for any airplane, so that the purchaser can know the relative weight per pound of thrust. Otto Herman, of the Century Rotary Motor Corp., mentioned a new type of engine, which he later stated to be of the semi-Diesel type, that has been developed by his company and extensively tested by the Army and the Navy. The cowling gives 15 to 20 per cent more speed, he said, and a 340-hp., 14-cylinder air-cooled engine has run 40 hr. on a fuel consumption of 0.30 lb. per b.hp-hr. Another model, a 180-hp. engine of 557 cu. in. displacement, operating at 1600 r.p.m. showed a consumption of 0.282 lb. per hp-hr. with cowling in place.

Cooperation of the airplane and the engine manufacturers is desirable in determining whether the exhaust collector should be radial or in line, and air-cooled or water-cooled, according to Walter C. Clayton, of Metal Aircraft, as the collector is difficult for the airplane manufacturer to apply and is a source of fire hazard. The design and development of a satisfactory exhaust manifold presents a problem, commented Chairman Jones, as it seems necessary to fit the manifold at least partially into the design of the airplane, and furnishing a manifold with the engine would interfere with the designer's latitude of choice.

Diesel Aircraft-Engines

Captain Woolson's paper on Diesel Engines for Aircraft more than justified the expectations of his hearers,

Members Who Took an Active Part in the Powerplant Session

Capt. L. M. Woolson (Upper Left), Aeronautical Engineer of the Packard Motor Car Co. and Second Vice-President of the Society, for Aeronautics, Discussed Diesel Engines for Aircraft; E. T. Jones (Upper Center), Chief Engineer of the Wright Aeronautical Corp., President; S. D. Heron (Upper Right), of Wright Field, Advocated Non-Radial Air-Cooled Engines; Charles L. Lawrance (Lower Left), President of the Wright Aeronautical Corp., Took an Active Part in the Discussion; A. V. D. Willgoos (Lower Right), Chief Engineer of the Pratt & Whitney Aircraft Co., Presented the Paper Prepared Jointly by L. S. Hobbs and Edward Hubbard on the Maintenance of Air-Cooled Engines in Commercial Operation

notwithstanding they were obviously disappointed in not learning something specific regarding the design of the new Packard experimental engine and failed to draw out the speaker more fully by questions asked in discussion. Commenting upon the paper after its delivery, Secretary Warner stated that "If this meeting had nothing but Captain Woolson's speech on the status of Diesel engines and the future prospects as he sees them, I am sure we would all have been more than justified in coming to Chicago to hear it."

The nature of the paper is indicated by one of the introductory paragraphs reading in part:

> Although we have designed and actually tested a Diesel airplane-engine for several hundred hours, the description of this engine in all its mechanical details is considered outside the scope of this paper, not only because the engine is still in the experimental stage, but because the general subject of Diesel engines for aircraft is worthy of a discussion in some of its broader aspects.

Captain Woolson contrasted the constant-pressure cycle of the Diesel engine with the constant-volume cycle of the gasoline engine and discussed at some length the mixed constant-pressure-constant-volume cycle, the efficiency of which has been proved by a specific fuel consumption of 0.35 lb. per b.hp-hr. The mixed cycle, which he regards as indispensable in high-speed, compression-ignition engine operation, is therefore preferable as to both power and economy. As combustion must start considerably ahead of top dead-center and continue while the piston approaches top dead-center, the designer is confronted with the problem of designing an engine in which the maximum cylinder pressures reach the high value of 1200 lb. per sq. in. Nevertheless, the Packard Diesel engine weighs less than 3 lb. per hp. and has been subjected to considerable flight testing as well as ground testing at speeds of 1700 to 1800 r.p.m. and is fully capable of withstanding cylinder pressures well in excess of 12000 lb. per sq. in.

Among the attractive aspects of the Diesel engine, the speaker cited as of greatest present interest the reliability that results from elimination of the electrical ignition and the carburetion systems. Failure of fuel injection or of ignition in any cylinder does not stop the engine, as each cylinder has independent injection and ignition.

Low Fuel Consumption and Cost

Economy in fuel consumption and reduction, if not total elimination, of fire hazard were discussed as other outstanding Diesel-engine advantages, the author ranking the latter as of far more importance. In a chart, comparison was made of actual aircraft-engine fuel-consumption ranging from 0.45 to 0.55 lb. per hp-hr. for gasoline engines and high-speed Diesel-engine consumption ranging from 0.35 to 0.53 lb. per hp-hr., both at cruising engine-speeds of 1350 to 1900 r.p.m. The curve for the Diesel engine represented the average of many tests. Fuel consumption of the Diesel-engine costs about 0.35 cents per b.hp-hr. as against 1.70 cents for the gasoline engine using aviation gasoline costing 19.8 cents per gal. Thus the fuel cost is about one-fifth as much for the Diesel as for the gasoline engine. Compression ratios as high as 18 to 1 have been used in the development work, such ratios assuring prompt starting and satisfactory performance at altitudes represented by the ceiling of the Stinson-Detroit airplane used in the tests.

Numerous minor advantages of the Diesel engine were pointed out by Captain Woolson, who in conclusion prophesied that airplane design will be affected because the great reliability of the Diesel engine will make the use of more than one powerplant unnecessary.

Replying to questions asked in discussion, the speaker stated that the minimum fuel consumption of 0.35 lb. per hp-hr. was with nine cylinders operating; and most of the test runs were made at 1700 to 1800 r.p.m., but at full speed in the air the engine operates at 2000 r.p.m.; and that a temperature of 450 deg. fahr. at the hottest spot in the cylinder-head is regarded as high. Lack of synchronization of the fuel-pumps creates no difficulty, because of the extremely flat engine-characteristics; and the cheaper grades of oil work better, he said, than the furnace oil, which is the only kind of Diesel-engine oil available in Detroit. The viscosity of this oil is entirely satisfactory for all operating temperatures, and no trouble has been experienced from the trapping of oil in the fuel lines, because of the working out by Dr. Fornier of a method of avoiding this possibility.

Commercial Aviation Considered

Papers on Production Cost, Fog-Flying, Care of Passengers, and Needed Improvements Presented

FOUR instructive papers were presented at the Commercial Aviation Session on Wednesday afternoon. W. C. Naylor, who presided, said in his opening remarks that a different type of airplane from that of the present must be provided if the job of selling the airplane to the commercial market is to be completed. One of the main purposes of the Society's meetings, he continued, is to try to arrive at some conclusion as to how this can best be accomplished. New ideas should be advanced and given consideration; for example, at the Aeronautical Exposition in Washington last year it was suggested that the research departments of the Government make a study of the cowling of aircraft engines. This was done and recently the National Advisory Committee for Aeronautics published a report on a type of cowling that reduces the drag of commercial fuselages about 40 per cent. That was a result of the cooperation of commercial manufacturers and operators with the Government's research engineers.

L. C. Milburn, chief engineer of the Glenn L. Martin Co., was the first speaker, his subject being Production Costs versus Quantity. Because of their bearing on the future manufacture and marketing of airplanes, he referred to studies of production cost figures, mentioned recently by F. H. Colvin, in *American Machinist*, which show that the labor cost of manufacturing an automobile in the $1,500 class is less than one-half the cost of selling the car and that, while the manufacturing cost is reduced by increasing the number produced, the selling cost tends to increase as larger quantities are forced upon the market. Even so, it is desirable to reduce the cost of manufacturing.

Production cost does not decrease in a smooth curve as the quantities made increase, said Mr. Milburn, but has hills and valleys resulting from quantity procurement of material, advantages of location or other causes independent of production circumstances. The former practice of making selling prices on current cost, with reductions as occasion seemed to warrant, has been followed by a more recent theory that cost should be computed upon a prediction of the extent of the market and the selling prices determined in accordance with these data.

Between the high cost of small quantities and the horizontal portion of the cost curve for large quantities are many important influences that affect the cost. The material selected must be suited to rapid methods. So long as quantities are not large, the tubular welded structure results in satisfactory cost, but too much hand-welding is required for large production. Sheet metal lends itself best to rapid fabrication methods and is uniform in quantity.

A second influence on cost is the design, and the designer should have in mind the quantity to be manufactured. Present quantities warrant liberal use of machine stampings, said Mr. Milburn, and as a rule favorable cost results when all detail parts are designed for machine-tool operations and for quick and easy assembly. Design, tooling and labor cost form three sides of a triangle, each influenced greatly by the other two. As quantities become large, the labor cost per piece is more important than the design and tooling cost, and it becomes profitable to spend more time on these items. This has presented a hard problem in aircraft manufacturing because of the difficulty of predicting quantity and cost. Overtooling for a model that fails of a good demand may prove disastrous, while conservative tooling for a model that later becomes popular may necessitate interrupting the production for retooling at a critical time.

Floor space is closely allied with tooling and is reflected in the cost curve, said Mr. Milburn, as too much area increases overhead cost while nothing is more costly than cramped quarters. Aircraft manufacture is especially complicated in respect to assembly-line timing, as a change in design or material may upset coordination of the department and a wide variety of influences affect the orderly flow of parts.

SPEAKERS AT THE COMMERCIAL AVIATION SESSION

W. G. Herron (Upper Left), of the Boeing Air Transport, Told What Is Necessary for the Care of Air Passengers; W. C. Naylor (Upper Center), Chief Engineer of the William B. Stout Engineering & Finance Co., Presided; E. P. Lott (Upper Right), of the National Air Transport, Presented a Critique of Airplanes; L. C. Milburn (Lower Left), Chief Engineer of the Glenn L. Martin Co., Described the Relation of Production Costs to Quantity Produced; Lieut. A. F. Hegenberger (Lower Center), of Wright Field, Outlined Fog-Flying Possibilities; Anthony H. G. Fokker (Lower Right), Enlivened the Discussion

The time is now here, he said in conclusion, when an airplane designer must seriously consider, not only the aerodynamic excellence and structural integrity of the product, but also the far-reaching effect produced on cost curves by variation in design practice.

Passenger's Safety and Comfort

W. G. Herron, of the Boeing Airplane Co., next presented a paper by Mr. Boeing. In preparing to embark in regular passenger service between Chicago and the Pacific Coast, said the speaker, four transports capable of carrying 12 passengers with their baggage and 1200 lb. of mail were being operated on the route by the Boeing Air Transport, but, owing to the great increase in air-mail loads, they were reserved for the mail service until about Jan. 1, 1929, when new air-mail planes will be completed at the Boeing factory. Meanwhile the pilots were becoming familiar with the operation of the tri-motored transport planes. These are provided with deeply upholstered adjustable seats; individual reading lights; cabin instruments showing altitude, airspeed and time; lavatories provided with hot and cold water; and a buffet service. The cabin, which has a height of 73½ in., is one of the few which permits movement of passengers without stooping. The plane will continue in full flight with any two of the three engines running, and level flight can be maintained on one engine. Rest rooms are provided at each landing-field and meals are furnished.

Regarding future developments, the author stated that 18 and 20-passenger transports are now under construction, that full dining service is offered in crossing the English Channel, and that transports with sleeping berths are but a stride in the future. The Boeing Air Transport mail planes and air transports are being equipped with radio telephones to put the pilots in constant communication with the ground stations, and radio telephonic service for passengers will be available in course of time. It is no idle dream, according to Mr. Boeing, to predict that commercial airplanes will be equipped with mechanism similar to that which enables naval landplanes to alight on a ship's deck, so that commercial airplanes can make use of small landing-fields in the heart of congested business districts. It is reasonable to expect also that future flying schedules will be based upon speeds of 150 to 200 m.p.h.

For passenger comfort, transport airplanes should have large individual seats with reclining back, sufficient foot-room, movable foot-rests, head cushions, arm rests, ample aisle width, adjustable indirect ventilation other than the opening of windows, and adequate heaters. A clock, an air-speed and an altitude indicator conveniently located and of sufficient size to be visible to all passengers while seated are needed. Suitable provision should be made for passengers who may become air-sick, and cabin lavatories should be as fully equipped and as sanitary as possible. Stewards are indispensable on trips of five hours or more.

Passengers and mail should not be carried in the same airplane, according to Mr. Boeing. Consolidated ticket-offices are provided in several cities, as in Chicago. A loading or run-up stand should be located near the waiting-room at the landing-field, and a concrete walk covered by a canopy should extend to the stand.

The Fog-Flying Problem

Lieut. Alfred F. Hegenberger, of the United States Air Corps, next presented a comprehensive paper on fog-flying possibilities. After describing the nature of fog and the dangers and difficulties of flying and landing in it, he told of the various instruments now in use as aids to the human senses in blind flying. The three classes of fog-flying problems are maintaining direction to the airport, localizing the airdrome, and determination of altitude. The speaker described devices used for each of these purposes and pointed out their limitations. Current, bank and air-speed indicators, or a combination of the three instruments in one unit, are employed for maintaining straight level flight; the radio beacon is used for maintaining direction to the airports, and the latest improvement in this line is a vibrating-reed visual indicator to warn the pilot when he is veering off his course. For determining altitude of the airplane above ground, Lieut. Hegenberger mentioned the open-scale precision altimeter provided with an auxiliary barometric scale, the electrical-capacity altimeter, and radio-wave and sound-wave reflection.

Fog penetration is greatest by radio wave, and, in the visible spectrum, by yellow rays. Research is now being conducted at Wright Field into penetration by various wave-lenths with frequencies outside of the visible spectrum. Two great difficulties are the obtaining of a sufficiently powerful source of emission and the developing of a selectively sensitive receiver that is rugged enough for airplane use.

No proposed method of dispersing fog offers a practical solution of the difficulty, and the author advocates experiments in landing through fog with an airplane having a landing-speed of 25 to 30 m.p.h., stability at stalling speed, controllability of stalling speed, and safety in event of a crash.

Airplane Construction Criticized

Modern commercial airplanes were criticized constructively in the paper by E. C. Lott, manager of operations of the National Air Transport. How economically does the airplane do its work? is the question in which the operator is vitally interested now, because any shortcomings an airplane may have are reflected eventually in the bank account of the operator. Since rapid developments render an airplane obsolete in two or three years, the rate of development being almost directly proportional to the fund of experience gained by the designer, the purchaser should make sure that the aerodynamic performance of a new design is sufficiently in advance of the requirements of its particular class to enable him to reap some benefit from the development of it in his own service. On his part the manufacturer should build a new design and fly it as hard as possible before attempting to go into production.

The author divided commercial airplanes into 100, 200, 400 and 600-hp. classes. Summing up the types of construction used, he said that the airplane having a steel-tube fuselage, wooden wing-frame, and fabric covering is most easily repaired, but also requires most attention to keep it in repair. Very little maintenance is required to keep the all-metal duralumin airplane in service but more experienced repair men are needed. In the long run the latter type of construction should be the best.

No good reason exists for a commercial airplane not being inherently stable under any normal position of loading and at the same time being as maneuverable as is necessary. When trimmed for longitudinal stability by the adjustable stabilizer so that no load is on the sticks at any throttle setting, the airplane should maintain the same air-speed with a variation of not more than 10 per cent either way; laterally, it should have a definite tendency to right itself without excessive yaw when displaced about its longitudinal axis; and directionally it should maintain a substantially straight course when the pilot removes his feet from the rudder controls. These necessary characteristics can be built into a commercial airplane without affecting the controllability or maneuverability adversely, according to Mr. Lott.

To perform his task most efficiently, the pilot must be afforded comfort, have controls and instruments properly placed, a universally adjustable seat and adjustable rudder-pedals. Other requirements include suitable grouping of instruments, a cockpit heater, ample visibility, protection from drafts, and safety glass in the windshield and in cabin windows. For visibility and safety in landing, the author regards the forward location of the pilot in the airplane as probably best, although this is open to debate and many pilots prefer to be back of the wings.

Brakes, properly installed and serviced, are very useful to a pilot when taxiing and in bringing the airplane up to the hangar when strong winds are blowing. They more than justify their weight, but the hook-up must provide easy and instinctive operation in parallel with the rudder. If brakes are installed, the need of a steerable tail-skid disappears, but the skid must be capable of swinging through a much greater arc unless the fuselage is built to withstand lateral stresses imposed by the skid when a sharp turn is made with one brake applied. A tail wheel would solve the difficulty but, to prevent accidental rolling in a wind, such a wheel should have a locking device, preferably operable from the cockpit.

Cowling must be easily and quickly removable, asserted Mr. Lott, who suggested a hinged cowl with latches like those of an automobile hood. Instead of control cables, which often pass through inaccessible parts, several push and pull-rod control-systems have appeared in the last 18 months, and the speaker expressed the hope that cable systems will disappear.

Substitution of oleo shock-absorbing systems for elastic cords has reduced landing-gear and tail-skid design troubles, as has also the general use of large tires. Apparently, however, the tendency has been to underestimate the loads imposed in taxiing over rough fields.

Adequate steps for the pilot and the mechanic should be built into the fuselage, and ample sidewalks should be placed on the wings so that passengers and mail can be loaded without damage to the wing covering.

In conclusion, Mr. Lott pointed out that streamline wires or cables exposed in a wing truss start to vibrate soon after ice begins to form on them and in many cases break shortly thereafter.

Pilots' Opinions Differ Widely

Anthony H. G. Fokker started the ball of discussion rolling in numerous directions when, in his characteristically humorous way, he referred to variegated demands of pilots regarding the position of the pilot's cockpit, visibility as affected by the angle of the windshield, and so on. These are matters of the highest importance. He thinks the pilot in a passenger-carrying airplane should sit in front, but in a mail plane he should be in the safest place. In the first commercial-type airplane built he put the pilot beside the engine, directly back of the propeller, so that he would have 100-per cent visibility, and he never had any pilot killed. His idea in building windshields sloping forward toward the top is to enable the pilot to see through them at an angle of 90 deg. when looking down preparatory to landing.

As for the difference in maintenance between an airplane having a steel-tube fuselage with fabric-covered wooden-wings and an all-metal airplane, Mr. Fokker said that the experience of operators is not sufficient to warrant a decision. He favored, with Mr. Lott, providing steerable tail-skid pedals that the pilot can operate without needing to think where to put his feet, just as he operates the rudder, and said that the pilot should operate the brakes the same as he operates the wheel.

Much discussion ensued regarding windshields and cabins, participated in by Chairman Naylor, Mr. Fokker and J. H. S. Skoning, general manager of the Chicago & Midwest Aircraft Co. Mr. Fokker asserted that the belief that the more glass there is in the cockpit the more a pilot can see is a fallacy, and Mr. Skoning pointed out that a great amount of glass causes confusing reflections from lights on the ground.

Passengers' Preferences Undetermined

In discussion on Mr. Herron's paper, a question by Mr. Fokker was answered by the author, who stated that no basis exists yet for determining whether passengers prefer to ride facing forward or backward, as most of the travel has been by persons making their first flights and they are interested in too many other things. The European lines find it difficult to induce passengers to make subsequent trips. After people have begun to make frequent trips by airplane, about the same percentage of opposition to riding backward will prevail as in railroad or street-car travel, Mr. Herron thinks. He criticized the airplanes exhibited at the show for their uncomfortable seats. Mr. Naylor referred to motorcoach chairs designed for different lengths of trip and suggested that airplane companies look into this practice.

Mr. Herron referred also to a statement by William B. Stout that the Junkers corporation in Germany is building a monoplane having a wing-spread of 148 ft. in which passengers will sit side by side in the wings and look through the leading edge. The craft is powered with eight 500-hp. engines.

Sliding windows of the automobile type provide too much ventilation at cruising speeds of 120 to 140 m.p.h., in Mr. Fokker's opinion. If someone opens a window, the passenger behind him gets all the blast, he said. So many possibilities exist of heating the air in the cabin that perfect ventilation can be obtained some other way. Mr. Herron agreed that it is desirable to have windows that will not open.

Standardization Progress

Many Subjects Considered and Subdivision Reports Discussed at Conference of Builders and Engineers

A GREAT amount of interest was evinced in the Standardization Session held on the afternoon of Thursday, Dec. 6, which was attended by engineers of airplane and engine companies and representatives of various accessory manufacturers.

An innovation has been introduced in the standardization work of the Society in the form of these conferences held for the purpose of discussing the work in progress by the Aeronautic Division and its various Subdivisions. In addition to the constructive criticisms and assistance in formulating specifications which are obtained for the various Committees, from men attending the meeting, opportunity is afforded for suggestion and discussion of new subjects for the standardization of which there is a need on the part of the industry.

The session in Chicago was the third of such aeronautic conferences and was divided into two parts to facilitate the discussion of the various subjects to be presented. The first half of the session was planned as a joint conference between the Commercial Airplane Manufacturers Section of the Aeronautical Chamber of Commerce and the Aeronautic Division of the Standards Committee of the S.A.E. It was presided over by J. Don Alexander, President of the Alexander Aircraft Co. and Chairman of the manufacturers' group.

Subjects Proposed for Study

Tail-wheel sizes and methods of landing were discussed, as were also tires for tail wheels, this being considered an important subject in view of the general trend from tail-skids to tail wheels on most of the larger airplanes. It was suggested that the Aeronautic Division give some serious consideration to determining a series of tail-wheel sizes, to prevent the confusion which will necessarily arise if many odd sizes of wheels are permitted to enter the picture. The matter was referred to the Subdivision on Tires, Wheels and Rims for consideration, together with its other problems.

It was further suggested that con-

sideration be given to streamline struts, as it appears that several strut sections are in existence at present, with no definite understanding as to what the dimensions should be. It was brought out that this matter is being considered by the AN Standards Conference, and that some report will shortly be rendered by that body.

The matter of a standard aviation gasoline was raised, but as this is at present engaging the attention of the Research Committee of the Society, in connection with a study of vapor lock, it was assumed that nothing can be done by the Standards Committee until the Research Committee's investigations are concluded.

C. N. Monteith, of the Boeing Airplane Co., requested that the Society give consideration to the question of heating and ventilating cabin airplanes. No data seem to exist at present on this important phase of cabin-airplane construction, and it is necessary that a determination of what constitutes satisfactory ventilation and the best means for supplying it should be made at the earliest possible moment, and some data published for the benefit of the builders.

The question of whether the Society should encourage or enter into international aircraft - standardization was raised. It was believed impracticable at this time to attempt anything in the way of international standardization, particularly of small parts, because of the two different systems of measuring. However, it was the opinion of many of those present that, because of the proximity of Canada and the fact that a large number of American-built airplanes probably will be in use by that country, some effort should be made in the Society's standardization work to coordinate the efforts with the various Canadian interests for the purpose of accomplishing interchangeability of parts.

Subdivision Progress Reports

That part of the session devoted to discussion of the progress reports of existing Subdivisions was presided over by Chairman Edward P. Warner. The first report was that of the Subdivision on Tires, Wheels and Rims, which was presented by B. J. Lemon, Chairman of the Subdivision. This covered wheel flanges, bolt circles, wheel loads, tire and rim sizes and weights, and was discussed in detail. The detailed report was brought up for further discussion at a meeting of the Subdivision later in December. The revised report will be printed in the Standardization Activities in a subsequent issue of the S.A.E. Journal before presentation to the Aeronautic Division for final consideration.

A great deal of interest was expressed in the research being carried on by the Aircraft Lighting Committee, which is preparing to install six sets of landing-lights on an equal number of airplanes of different manufacture operating in different sections of the Country for the purpose of ascertaining information as to proper beam-distribution and intensity for landing-lights, correct placement of lamps, and what adjustable features are necessary, if any.

A proposed revision of the tachometer-drive standard indicated considerable difference of opinion relative to the dimensions of such drives. This subject and the question of spark-plugs and flange-mounted magnetos are still in the hands of the various Subdivisions. Additional reports will be submitted at future meetings.

Judging from the nature of the discussion and the diversity of the subjects considered, it is safe to assume that there is sufficient cooperation by companies in the industry to assure proper study of standardization in the formative period of the industry, to the end that the chaotic condition which has so often developed in new industries will, to at least some extent, be avoided in the aeronautic industry.

Among Those Who Attended the Standards Conferences

(Left to Right) Arthur Nutt, of the Curtiss Aeroplane & Motor Co.; Lieut. C. B. Harper, of the Bureau of Aeronautics; and J. Don Alexander, of the Alexander Aircraft Co., Chairman of the Commercial Manufacturers' Section of the Aeronautical Chamber of Commerce of America

SOME OF THE COMMITTEE ACTIVITIES AT CHICAGO
(Left) Discussing Standardization After the Aeronautical Standardization Meeting, Presided Over by the Hon. Edward P. Warner and J. Don Alexander; (Right) Aeronautical Advisory Board Meeting, Presided Over by President W. G. Wall

Airship Design and Handling

Rigid and Blimp Construction, Mooring Mast and Handling-Truck Developments, and Propeller Efficiency Described

DOUBTLESS the recent successful round-trip transatlantic flight of the Graf Zeppelin accounted in part for the good attendance at the final session of the meeting on Thursday night, at which Dr. Karl Arnstein was scheduled to speak on Lighter-than-Air Aircraft Developments; Commander C. E. Rosendahl, of Shenandoah fame, on Recent Developments in Short Mooring Masts and Handling-Trucks; and Lieut-Commander C. H. Havill, on Airplane Propellers and Gearing. Acting as host to the Society's Aeronautic Meeting, the Chicago Section held a Get-Together Dinner preceding the Session, during which several interesting entertainments were featured. Almost 200 members and guests attended.

L. D. Seymour, of the National Air Transport, recently elected Chairman of the new Aeronautic Division of the Chicago Section, presided. He missed the Get-Together Dinner, he explained, because in the afternoon he had "the little job of transporting some of the distinguished guests from abroad by air from Cleveland to Chicago in a fleet of 12 giant three-engined airplanes, the largest number of such aircraft ever gethered together for such a purpose."

WALL VISIONS AIRCRAFT PROGRESS

President Wall, when called upon for some preliminary remarks, referred to the success of the two-day meeting as evidence that the Aeronautical Chamber of Commerce and the Society of Automotive Engineers make a good team. The number of exhibits at the Coliseum and of airports under construction throughout the Country make evident the great interest in aeronautics in the United States. To assure aircraft safety, he continued, we must have engineers experienced not only in design of the engines and the planes but in their maintenance. In this, the Society can be of great assistance, by papers presented at its meetings and through the standardization of airplane details. It is realized that the industry is in the formative stage; therefore there is no desire to standardize general designs or to discourage original ideas, he said; but good work will be accomplished if many of the details that probably will remain as they are for years can be standardized.

Comparing the progress of the automobile and the aeronautic industries, President Wall recalled that about 500 motor-cars were produced in 1899, and five years later the United States was producing 10 times as many. In 1924 the Country produced 500 airplanes, and either this year or next year we shall be producing 10 times as many as four years ago. If the same rate of increase continues, we shall have as many airplanes in 1953 as we now have motor-cars. An item of particular interest is that in the aggregate the airplanes today are selling for eight or ten times as much as the same number of automobiles at the same stage of the automobile industry.

Because Dr. Arnstein had to leave early, a change was made in the order of the program and he was called on to give his paper first. This consisted largely of explanations of the design of the Graf Zeppelin, the new dirigibles recently ordered by the United States Navy, and the relatively diminutive semi-rigid Puritan and Pilgrim, as shown in nearly half a hundred lantern slides. Dimensions of the Graf Zeppelin were limited, he said, by the size of the available construction hangar of the German Zeppelin company. No such restriction will hamper the design of the 6,500,000-cu.-ft. airships to be built for the Navy, as the Goodyear-Zeppelin Corp. has begun the erection of the world's largest hangar on the municipal flying-field at Akron, Ohio. This hangar, he said, will be 1200 ft. long, 325 ft. wide and 200 ft. high. It has been carefully designed to reduce wind pressure and avoid local regions of extreme pressure variations.

Adoption of a gaseous fuel having the same density as air was mentioned by Dr. Arnstein as a definite step in the right direction by the builders of the Graf Zeppelin, as it assures continuous static equilibrium and avoidance of the necessity of valving the lifting gas as fuel is consumed on a long trip. Various arrangements of fuel-gas and lifting-gas cells within the airship structure were shown.

Although flights of rigid airships have demonstrated their ability to withstand abnormal weather conditions and winds equal in velocity to the speed of the ship, it is imperative, asserted Dr. Arnstein, that they have higher speeds if regular service is to be maintained; and it is advisable that they be more rugged and compact.

THE NEW NAVY DIRIGIBLES

The airships ordered by the Navy are of a size and type exceedingly well suited for long-distance commercial ser-

vice. They are to be helium inflated and consequently will have a lifting capacity a little less than that of the 5,000,000-cu.-ft. Graf Zeppelin. Slides of the truss-type main rings of the hull, which are strong enough to take all stresses without wire bracing, were shown, as were also numerous features of the construction, such as the novel provision for storing five completely assembled airplanes within the ship. This compartment is located about one-third of the length of the ship from the nose and is about 75 x 60 ft. in size. At a top speed of 87 m.p.h., the ship will have a flight range of about 4700 miles and, at a cruising speed of 60 m.p.h., a range of nearly 10,000 miles. This is with a crew of 55 members, 40 passengers and 10 tons of mail and express.

The speaker emphasized the structural strength of the design, which is considerably greater than that of previous airships.

A unique feature is the location of the eight directly reversible engines inside the hull, connected to rigid drive-shafts extending outside the hull to the swiveling propellers. The use of bevel gears makes it possible to tilt the propellers 90 deg. on their axes and so to

(*Continued on p. 94*)

Speakers and Chairman at the Lighter-Than-Air Aircraft Session

Hon. E. P. Warner (Upper Left), Nominee for First Vice-President of the Society for 1929 and Member of the Aeronautic Meetings Committee; Lester D. Seymour (Upper Right), of the National Air Transport, Chairman of the Chicago Section Aeronautic Division, Who Presided at the Session; Dr. Karl Arnstein (Lower Left), Vice-President of the Goodyear-Zeppelin Corp., Who Told About Buoyant Airship Development; Lieut-Commander Charles E. Rosendahl (Lower Center), of the Naval Air Station at Lakehurst, Who Described Recent Developments in Short Mooring-Masts and Handling-Trucks; and Lieut-Commander C. H. Havill (Lower Right), of the Bureau of Aeronautics, Who Discussed Airplane Propellers and Gearing

Chronicle and Comment

Two Sections for This Number

THIS issue of THE JOURNAL consists of two sections, Section 1 being the regular monthly issue for January and Section 2 the Index to Vol. XXIII. For the last five half-yearly volumes of THE JOURNAL this practice has been followed; prior to that the index appeared in the last issue of each volume, in June and December respectively.

Any reader who fails to receive a copy of the semi-annual index as part of this issue of THE JOURNAL is requested to notify the Publication Department at the Society's headquarters in New York City, which will mail a copy to him.

Aircraft Standardization and Activities

THE general status of the current aircraft engineering standardization is indicated elsewhere in this issue of THE JOURNAL, in the section devoted to the account of the Aeronautic Meeting held in Chicago last month. The meeting of the Aeronautic Division in Chicago was noteworthy in that it was the first occasion at which the Aeronautical Chamber of Commerce was officially represented in the matter of that organization's interest in standardization. It is felt that the conference gave great promise of adequate continuing interest in and attention to rational aircraft standardization.

Among the most important things, the subject of propeller-hub and shaft-end dimensions is conspicuous. There is no phase of interchangeability more important in the use of aircraft than that of propeller-hubs on engines of different makes of comparable horsepower. The new mounting-dimension standards will go into effect immediately. In arriving at these, the aircraft-engine industry and the Army and the Navy have cooperated extraordinarily well in the movement that has been fostered by the Society and in which the Standards Department has been extremely active during the last year, with very gratifying results.

Another very helpful activity is the study being made by a Society Committee on the subject of aircraft lighting, with reference particularly to essential features of landing-lights. This work is naturally largely of research nature. The large commercial-airline operators, as well as the Army and the Navy, are cooperating very helpfully in conducting necessary tests. Various companies are furnishing the equipment needed for the tests and also supervising its installation. Undoubtedly, one of the greatest problems in aircraft operation is that of determining what illumination is necessary and how provision can be made for securing it with the addition of the least weight and head-resistance.

Significant figures that indicate the increasingly important part which aeronautics should have in the work of the Society are revealed by a recent analysis of the membership.

As pointed out in the general review of the Chicago Aeronautic Meeting on p. 1 of this issue, 5 per cent of the members of the Society are connected with companies primarily engaged in aircraft production, as compared with 1 per cent connected with motorboat, 2 per cent with tractor, 3 per cent with motorcoach, 9 per cent with motor-truck and 13 per cent with passenger-car companies. The actual number of members interested in aeronautics is much greater than this, as 40 per cent of the members are connected with companies manufacturing parts, accessories, and materials for automotive vehicles, which include airplanes.

On the basis of the number of design and research-engineer members connected with companies building complete vehicles, the comparison is startling. The aeronautical engineers take third place in the Society, the figures being: passenger-car, 41 per cent; motor-truck, 21 per cent; aircraft, 20 per cent; tractor, 8 per cent; motorcoach, 7 per cent; and motorboat, 3 per cent. As to members holding executive positions in the same companies, aeronautics takes second place, the figures being: passenger-car, 43 per cent; aircraft, 27 per cent; motor-truck, 16 per cent; tractor, 6 per cent; motorboat, 5 per cent; and motorcoach, 4 per cent.

In view of these figures, the percentage of aeronautic material in the S.A.E. JOURNAL will doubtless increase during 1929. The amount of aeronautical material published during the last two years approximated 15 per cent of the total text.

The Daniel Guggenheim Medal

THE Daniel Guggenheim Medal Fund, Inc., was formed for the purpose of awarding from time to time medals to be known as the Daniel Guggenheim Medal. Each such medal is to be awarded to a person in recognition of notable achievement performed by him which shall tend to the advancement of aeronautics. In the making of the award there is no restriction on account of race, color, nationality or sex, and no award is to be made to any person until at least one year after such person's name shall have been submitted to the Board of Award for consideration. The medal is not to be awarded more often than annually.

The following past Second Vice-Presidents who have served the Society during recent years as representing aviation engineering are members of the Board of Directors of the Fund: P. G. Zimmermann, E. P. Warner, Arthur Nutt, and E. T. Jones. They are also members of the Board of Award. From time to time the members of the Board of Award are to deliver to the Corporation reports and supporting data regarding achievements deemed notable in the advancement of aeronautics. Such reports are to be submitted by the Corporation to the Board of Award for consideration and action.

Any member of the Society interested in the matter and desirous of having the name of any person considered as nominee for award of the medal should address at the office of the Society one or more of the past Second Vice-Presidents of the Society named above. It is trusted that any member who wishes to suggest such name or names will do so and that his communication will be received at the Society office before Jan. 28.

A Third Stage in Aircraft Design

By J. G. VINCENT[1]

IN discussion of matters pertaining to engineering evolution we are prone to think of progress as a series of steps. As a matter of fact, all progress consists or more or less uniform growth, but it is convenient to set down arbitrary lines designating one step from the next.

It occurs to me that, in the case of airplane development, so many things happened during 1927 that we can very appropriately dust off and bring out some time-worn phraseology to say that 1927 brought in a new era of aviation development.

In this prophetic paper the author points to the year 1927 as having dispelled the fallacy that the sum of the weight of the complete airplane in pounds per horsepower and in pounds per square foot of wing area should not exceed 30.

The next important development to which we can look forward is an increase in the cruising speed of commercial airplanes to 150 m.p.h. in the near future, and ultimately to 300 m.p.h. It is the task of engineers to remove the limitations of parasitic drag and wing drag and to increase the propeller efficiency.

Dissatisfaction with the Otto cycle has resulted in intensive study of the application of the Diesel cycle to airplane engines.

Chief advantages of the Diesel-cycle engine are the use of a non-volatile, cheap fuel; a specific fuel consumption of approximately 0.38 lb. per b.hp-hr.; and the elimination of carbureters and electrical ignition-apparatus.

As cooling must be obtained ultimately with the minimum amount of drag, the radial air-cooled engine is criticized and the prediction made that eventually that type of engine will be chosen which gives the airplane the best performance, whether the engine be cooled by water, air, steam or otherwise.

We might well consider that the first stage in airplane development was represented by anything that would fly. This includes the pioneering work of the Wright brothers and the efforts of those who immediately followed, as Curtiss, Bleriot, and others.

I would distinguish the second stage of development from the first by saying that, whereas the first stage comprised anything that would fly, the second stage comprised anything that would keep on flying. This would bring us to and through the war period and take us up to the spring of 1927, when things began to happen which warranted a new designation in these steps of progress.

So, whereas the second stage has been considered to cover anything that would keep on flying, the third stage covers anything that will keep on flying effectively and economically; and this crude description embraces all those characteristics which are essential for consideration of aviation as a real means of commercial transport, so that the third stage portends the use of aircraft commercially as an accepted means of transportation of passengers or freight.

AIRPLANE LOADING INCREASED IN 1927

Although I do not desire to pose as an expert on aerodynamics, the one thought that predominates in my mind on the subject of this third stage is that the year 1927 dispelled a fallacy that had been spread by authorities on aerodynamics and which I accepted as gospel truth; that is, that the sum of the power loading and wing loading of an airplane expressed in certain units must not exceed a certain sum. In other words, I was led to believe that if the power loading was represented by pounds per horsepower for the complete airplane and the wing loading by pounds per square foot for the complete plane, the sum of these unit values must not exceed 30. For example, if an airplane weighs 4000 lb. and has a 400-hp. engine, the power loading is 10 lb. per horsepower; consequently the wing loading must not exceed 20 lb. per sq. ft. As a matter of fact, even this figure of 30 was regarded as high in 1926 and most airplane designs worked out to a sum of 25 or less for the combined wing-loading and power-loading.

Then in 1927 things began to happen. A whole host of cabin monoplanes were developed and flown with power and wing loadings which upset altogether our previous ideas on limitations in these directions. Lindbergh's airplane weighed about 23 lb. per hp. and carried nearly 20 lb. per sq. ft., or a total of approximately 43. Next came Chamberlin, who carried still more load in his Bellanca plane than did Lindbergh in his Ryan; and, finally, Mrs. Grayson, who was lost with the Sikorsky amphibian, The Dawn, claimed to have flown this airplane at Harbor Grace with a power loading of about 30 lb. per hp. and a wing loading of approximately 22 lb. per sq. ft., or a total of nearly 52.

To my mind the raising of these limiting values represents the outstanding aerodynamic achievement of 1927. It is true that, to a certain extent, all these flights were stunt flights, and specially prepared runways were necessary to get the heavily loaded airplanes into the air; but I believe we have a right to expect that similar runways will be available at all airports in the future, so that the hazard of long take-off runs will be diminished.

Granting that 1927 showed that airplanes can be loaded down much more than we previously thought possible and that we can use much smaller engines for a given load, what is the next important development to

[1] M.S.A.E.—Vice-president of engineering, Packard Motor Car Co., Detroit.

J. G. VINCENT

which we can look forward? To my mind it is an improvement in the cruising speed of airplanes for commercial service; and this improvement is to be obtained by increasing the power or by decreasing the parasitic resistance.

Today 100 m.p.h. is regarded as the average cruising speed. I believe that we can anticipate cruising speeds of at least 150 m.p.h. in the near future, and that aviation cannot begin to consider itself full-grown until cruising speeds of about 300 m.p.h. are realized. The need for higher cruising speeds is apparent from every viewpoint. At 100 m.p.h. in the air one seems to be standing still, and flying becomes very monotonous; it compares with driving an automobile on a straight stretch of concrete highway at about 5 m.p.h. as regards the attention needed by the pilot to keep on his course.

Granting that operating conditions set almost no limit on the top speed or the cruising speed of an airplane, it can be seen that it is strictly the task of engineers to remove the engineering limitations which stand in the way of higher speed. These limitations are mainly of one kind; they come under the head of drag and include resistance of two kinds: parasitic resistance and the drag of the wings which is necessary to obtain lift. Another item of no inconsiderable importance is that of propulsive efficiency, a much neglected subject which only begins with propeller efficiency and ends when the thrust of the propeller is put to useful work in advancing the airplane by virtue of the reaction of the slipstream, rather than in retarding the plane by reflecting the slipstream back upon the large exposed areas of the fuselage, wings and tail surfaces.

Desirable Engine Characteristics

We now come to considerations of what are desirable characteristics in aircraft engines in the future and what should be the trend of development. I believe the subject can best be handled under two headings:

(1) A consideration of the cycles to be used

(2) A consideration of the general arrangement of the engine, particularly with respect to its cooling requirements

The Otto cycle, used universally for aircraft engines at present, has been inherited from the automobile industry and was adopted in the first place because the gasoline engine represented the lightest known prime mover available for the purpose. The same condition still obtains, but there is an increasing amount of dissatisfaction with the limitations of the Otto cycle.

Dissatisfaction with the Otto cycle for aircraft use rests mainly on the lack of robustness of the engine in large sizes or, rather, dependence on too many delicate mechanisms. A 1000-hp. engine may become absolutely useless, so far as propelling an airplane is concerned, if electrical failure occurs in any one of a number of duplicate parts which may weigh not more than an ounce apiece. Spark-plugs, while fairly satisfactory in ordinary service use, will not last two minutes when we attempt materially to increase the compression ratio in the laudable effort to obtain more power and better fuel-economy. A drop of oil in a certain place is all that is needed to put a spark-plug out of use; two drops will put one cylinder out of action and thus eliminate one-ninth or one-twelfth of the power, as the case may be. Furthermore, we are dealing with a highly expensive, volatile fuel which has caused the death of many aviators who would have been alive today if the airplanes in which they suffered minor crashes had not been destroyed by fire immediately thereafter.

Diesel-Cycle Field Being Explored

Those interested in the ship-of-the-air could not but be jealous of the results obtained with the new ships-of-the-sea utilizing internal-combustion engines to such great advantage. From the viewpoints of load requirements and the necessity for reliability and durability, ships-of-the-sea and ships-of-the-air have everything in common; so it does not require very keen conception to make the statement that there is bound to be an interchange of knowledge and experience which will seriously affect the evolution of the powerplant.

The Diesel cycle is now being explored for application to airplane engines by investigators all over the world. Our excellent Government laboratories at Langley Field, conducted by the National Advisory Committee for Aeronautics, are working on this problem virtually 100 per cent. The British are doing likewise, and the Germans have, of course, pioneered this work and are well on their way toward a successful solution. The Packard Motor Car Co. has built and flown Diesel-cycle engines and is now putting them through exhaustive tests.

The advantages of using a non-volatile, cheap fuel are so obvious that no discussion is necessary; and, when the use of this fuel is accompanied by economies represented by specific consumptions of approximately 0.38 lb. per b.hp-hr. as against 0.50 lb. per b.hp-hr. for the gasoline engine, it is clear that no further arguments are needed. When, in addition to these two tremendous advantages, we secure compression ignition and eliminate all of the delicate electrical ignition-apparatus and the carbureters, which do not function nearly as well in the air as they do on the ground, it can be realized that the development of a simple Diesel-type aircraft engine is urgently needed.

The second phase of powerplant development which I desire to discuss is engine form, which is influenced as much by the cooling requirements as by anything. At present there is such a world-wide enthusiasm for air-cooled engines that I do not dare to raise my voice and prophesy that the air-cooled engine may not be the ultimate engine after all. I prefer to make a different kind of statement, saying that the cooling of the ultimate aircraft engine must be obtained with the minimum expensive drag if we are to increase the cruising speeds to 150 m.p.h. in the near future and to 300 m.p.h. eventually.

We certainly cannot obtain such speeds economically or effectively with a series of finned cylinders projecting out into the slipstream. Each of these cylinders represents the worst kind of interference, because of both its circular shape and the mutual interference between the fins and all the other protuberances of the modern radial air-cooled engine.

Investigation has shown that the ideal airplane should have a fuselage of circular cross-section and that the powerplant should blend into such a fuselage. If multi-engines are used, the same applies to the separate engine nacelles. Therefore, we can look for aircraft-engine design to follow along lines which will produce such a powerplant. I am certain that the engine which ultimately will be chosen for aircraft will be the one which gives the best performance to the airplane, whether it is cooled by water, air, steam or otherwise.

Aircraft Propellers

By Lieut-Commander Clinton H. Havill[1], U. S. N.

Chicago Aeronautic Meeting Paper — *Illustrated with* Photograph and Charts

Nearly all the aircraft propellers used by both the Army and the Navy are of the detachable-blade type. The Navy has found it necessary to make its own designs and to furnish the propeller manufacturers with finished detail drawings. The author lists the sources from which data can be obtained and shows a chart from which can be found a diameter and setting of a pair of detachable blades that will give reasonably good performance for nearly any horsepower, revolutions per minute and airspeed commonly used with the direct-drive type of propeller.

Discrepancies between model tests and wind-tunnel tests are cited, and the author then considers the subject theoretically. Substitute propellers are next considered, and also the strength of propellers. The author gives empirical formulas for maximum fiber-stress and explanations of them, describes the whirl-test for strength, discusses the necessity for the use of gearing, and enumerates the considerations that apply to variable-pitch propellers.

Design of aircraft propellers of the detachable-blade type, adjustable in pitch on the ground, has become a special branch of aeronautical engineering. This type of propeller has primarily been developed in this Country, and nearly all the propellers used by both the Army and the Navy are of this type. The Navy has found it necessary to make its own designs and to furnish the propeller manufacturers with finished detail drawings. These designs are largely used in commercial aviation, designated by the manufacturer's number instead of by the original design number. The reason for this is that, for a given type of engine and airplane and for a given airspeed, the Army and the Navy have developed a propeller blade that "fits" the airflow; and for similar conditions the commercial operator secures the benefit of the design and experimentation on propellers that the military services have found necessary. A detachable-blade type of aluminum-alloy propeller is shown in Fig. 1.

Fig. 1—Detachable-Blade Type of Aluminum-Alloy Propeller

It seems logical to ask if, from all the propeller literature and the hundreds of previous types of plane, it is not possible to furnish a propeller that is the best for those conditions. The answer is that it is possible to furnish a propeller that is accurately designed and that will give excellent performance; but it will not always be the best propeller.

Although the difference between a good propeller and the best may appear small to the average pilot, yet when such factors as fuel consumption per mile and ability to take off with a very large load are considered, it can be seen that the best propeller for a given plane must be especially suitable for the things that the plane is designed to do. To provide such a propeller, the designer often must sacrifice 1 to 2 m.p.h. of top speed to favor a higher rate of climb, as is done in some types of fighting plane. In other cases it may be necessary to sacrifice a small amount on rate of climb to favor fuel economy at cruising speed.

Best top-speed seldom is given by the propeller that is best, all things considered, except in racing planes. However, in racing planes, the ability to change the top speed by small changes in the design of propeller is limited usually to a small percentage of the total speed, as, in racing, the propeller works under conditions that favor high efficiency, if the diameter is nearly correct; and the speed changes only as the cube root of the change of efficiency, expressed as a percentage. Horsepower and "clean design" of plane are the items that win most aircraft races.

Sources of Designer's Information

The designer of aircraft propellers has several sources of information, no one of which, except experience, is sufficient in itself always to give the best propeller at the present state of the art. These sources may be tabulated as follows:

(1) Pure theory
- (a) Momentum theory
- (b) Blade-element theory (Drzewiecki, 1909)
- (c) Combined momentum and blade-element theory, giving rise to a modified theory
- (d) Prandtl's theory of wings, developed by Betz to apply to propellers and finished in practical form by Glauert

(2) Wind-tunnel tests
- (a) Model tests
- (b) Full-scale tests, with and without fuselage (now being carried on by the National Advisory Committee for Aeronautics)

(3) Analysis from actual service-flight tests

A great amount of pure theory is available, and nearly as much in the way of data from wind-tunnel tests is at hand in various forms; but not very much has been published based on free-flight tests of metal detachable-blade propellers.

Chart Based on Propeller Analyses

Fig. 2 shows the results of the analysis of a large number of service propellers for various types of airplane. Cases were chosen in which the propeller performance was considered entirely satisfactory, if not the best; so, by following the instructions on the chart in

[1] Bureau of Aeronautics, Navy Department, City of Washington.

Fig. 2, a diameter and setting for a pair of detachable blades can be found that will give reasonably good performance for nearly any horsepower, number of revolutions per minute and airspeed commonly used on direct-drive propellers today.

To use the chart: (*a*) enter it with the airspeed, and from the r.p.m.-curve pick off K_p and the desired setting at the 42-in. station; (*b*) solve for D^4, using formula $HP/K = D^4$. Then enter the table with the value of D^4 and pick out the value of the diameter in feet and inches.

This chart cannot be used backwards; for example, if a plane normally makes 140 m.p.h. and then, from the chart, a propeller is chosen which is of the diameter and setting for a 150-m.p.h. plane, the 150-m.p.h. propeller probably will give a speed of only about 135 m.p.h. to the plane having a normal speed of 140 m.p.h. Horsepower available and propeller-limiting efficiencies prevent the chart being used in the reverse order. It is the same as in any other branch of transportation, the power available and the efficiency attained govern the performance.

Fig. 2 was produced by me in the Propeller Section of the Bureau of Aeronautics for general office use. It furnishes data for a propeller based on the mean of previous performance and will give a propeller of good propulsive efficiency, though not always the best propeller, as will be explained later.

Theory versus Practice

Before proceeding it should be stated that the results of pure theoretical study, wind-tunnel tests and actual service use are not in entire agreement. Pure theory is, of course, the basis of all real progress in any branch of engineering and, as such, must be kept constantly developed. A solid groundwork of pure theory in propellers is necessary if one is to attempt to extend practical results properly from one condition to some other assumed condition.

Wind-tunnel tests of model propellers is the next step. Model tests have greatly aided in furnishing the modification necessary to "pure theory" and have served to develop the blade-element theory to the point at which a propeller can be designed accurately. Use of the radial air-cooled aircraft engine has necessitated many changes in the previous methods of applying model tests to actual use.

There are a number of sources of discrepancy between model tests and the full-scale tests, and also among the full-scale tests themselves. The most common one is the well-known scale-effect that is assumed to depend on the Reynold's number, which is a non-dimensional number depending on the size of the model, the velocity of the air, and the density and viscosity of the air during the test. The theory of similitude shows that, for the same value of Reynold's number, the same airflow and forces exist; however, this does not appear to hold exactly true for propellers when other factors such as tip-speed are varied also.

A second source of discrepancy is the tendency of the propeller blades to distort under load, causing changes in the nature of the flow across a propeller blade. This is especially important if the pressure distribution is altered on account of change of flow.

A third cause of differences is the interference of the engine, fuselage and airplane adjacent to the propeller. These interferences change the inflow and greatly affect the propeller performance as well as causing a turbulent slipstream, with its consequent higher drag on all parts of the airplane in contact with it.

A fourth cause of discrepancy is the change in flow occurring at high tip-velocities. This change in flow, which may be a compressibility effect near the velocities of sound, or about 1100 ft. per sec., has been investigated and much has been written on the subject[3]. However, all propellers seem to lose some efficiency for tip speeds beyond 900 ft. per sec., and the amount of this depends on the ratio of blade thickness to blade width for sections near the tip, the type of airfoil used, the angle of attack, the pitch and the pitch distribution.

In view of these principal discrepancies, it is not surprising that propeller-model tests cannot be used directly for full-scale propellers. For example, the net result of the application of 30-in.-diameter-model tests is that the power coefficient obtained on a model must be multiplied by 1.36 as an average correction to apply to the power coefficient used on 9-ft.-diameter geometrically similar propellers.

Model tests have their proper usefulness in the propeller art, but there are too many idiosyncrasies in trying to use empirical correction-factors for full-scale actual propellers. But, as a matter of convenience, model tests are of more actual use than the direct application of pure theory in the abstract.

Full-Scale-Propeller Wind-Tunnel Tests

The conflicting results of all these previous labors has led the National Advisory Committee for Aeronautics to build a 20-ft.-diameter wind-tunnel so that a full-scale propeller can be tested together with its engine and fuselage. The results obtained on the first tests made recently have been somewhat disturbing. Compared with expected values, the power coefficients appear low and the efficiencies slightly high, while the thrust apparently agrees closely with previous methods of calculation. The method of testing is to measure the thrust and torque of the actual propeller while driven by the engine. From these quantities, thrust and power coefficients are calculated so that, for other conditions, the results can readily be attained.

The following formulas are used based on similitude:

$$T = C_T \rho N^2 D^4 \tag{1}$$

$$Q = C_Q \rho N^2 D^5 \tag{2}$$

$$P = C_p \rho N^3 D^5 \tag{3}$$

where C_P, C_Q and C_p are functions of V/ND, curves being plotted of these functions.

The symbols used, in English units, are as follows:

T = Thrust, in pounds
ρ = Mass density of air in the tunnel, w/g or $1g$ times the number of pounds per cubic foot
C_T = Non-dimensional thrust coefficient
N = Number of revolutions per second
D = Diameter of propeller, in feet
Q = Torque, in pound-feet
P = Brake horsepower = Power in foot-pounds per second
C_Q = Non-dimensional torque coefficient
C_p = Non-dimensional power coefficient
V = Airspeed, in feet per second

In theory, C_T, C_p and C_Q remain constant for a geometrically similar propeller operating at the same

[3] See National Advisory Committee for Aeronautics Reports Nos. 83, 207 and 255; also, British Aeronautical Research Committee's Reports and Memoranda Nos. 884, 1086, 1123 and 1124.

V/ND. The same values of thrust coefficient, C_T, and power coefficient C_p, could be used for free-flight theoretical computations provided the coefficients were obtained at full scale in the wind-tunnel. However, this application does not seem to work out in practical propellers, because the wind-tunnel power-coefficients are usually low. Various explanations have been advanced, but the most commonly accepted one is that, in the wind-tunnel, an "artificial inflow" is caused which lowers the power and thrust coefficients. This lower thrust results in less distortion of the blade than is found in free flight, while wind-tunnel efficiency is usually 2 to 3 per cent higher than free-flight analysis indicates.

An example of the actual efficiencies attained in free flight with one particularly thin blade used on direct-drive air-cooled engines is shown in Fig. 3. This blade is an example of one having low uniform-pitch but turned up to higher effective-pitch. This gives rise to a non-uniform pitch-distribution along the blade. For example, this particular blade, Bureau of

$D=K\sqrt[4]{\frac{Hp.}{N^2V}}$ D=Dia. Ft. N=R.p.m. V=M.p.h. Values of K	Mean Slip at 42-In. Station, per cent	$\frac{Hp}{K_p}=D^4$ Table and (Diameter)[4]	
		Diameter To Use Ft. In.	D^4 Ft.
		8 3	4096
		8 4	4270
273.0	11.50	8 5	4449
		8 6	4633
		8 7	4822
273.5	11.46	8 8	5019
		8 9	5220
		8 10	5427
274.0	11.43	8 11	5643
		9 0	5862
		9 1	6087
275.1	11.36	9 2	6322
		9 3	6561
276.5	11.31	9 4	6806
		9 5	7062
		9 6	7321
280.0	11.19	9 7	7587
		9 8	7864
		9 9	8145
284.0	11.09	9 10	8433
		9 11	8733
		10 0	9037
289.2	10.98	10 1	9347
		10 2	9672
		10 3	10,000
297.0	10.83	10 4	10,336
		10 5	10,685
		10 6	11,038
305.0	10.69	10 7	11,400
		10 8	11,775
		10 9	12,155
308.7	10.35	10 10	12,544
		10 11	12,947
		11 0	13,355
312.0	9.20	11 1	13,772
		11 2	14,204
		11 3	14,641

FIG. 2—DATA FOR TWO-BLADED METAL PROPELLERS, DETACHABLE-BLADE TYPE

The Chart Reproduced Below Is Used in Conjunction with the Table at the Left To Find the Diameter of the Propeller and the Setting of the Blades When the Horsepower, the Number of Revolutions per Minute and the Airspeed Are Known. It Gives the Diameter, Blade Setting and Horsepower Required, and Is Based on Data Obtained from Successful Navy Propellers in 1928 and from Some Prior Racing Airplanes. The Tabulation for the Navy Standard Blade-Section Comprises Most of the Needed Data for Airspeeds below 160 M.P.H. That for the Clark-Y Blade-Section Includes Data for Airspeeds above 160 M.P.H. The Average Fineness-Ratio Is 5.8

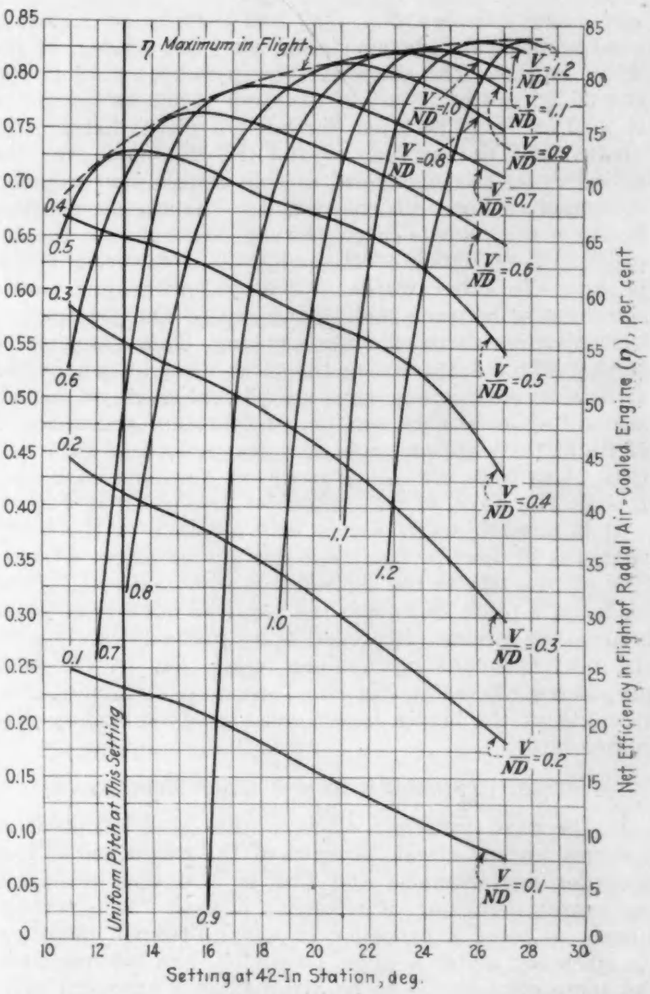
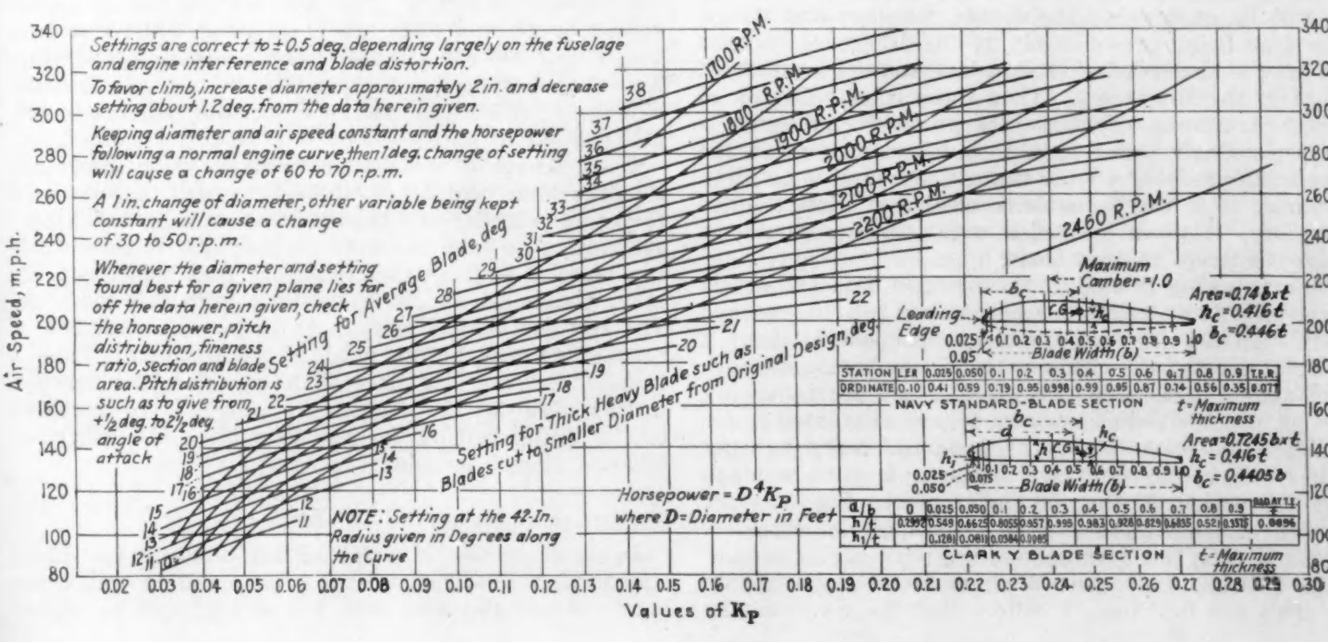


FIG. 3—ACTUAL EFFICIENCIES ATTAINED IN FREE FLIGHT

The Data Were Obtained When Using a Two-Bladed Propeller of 9-Ft. Diameter with a Radial Air-Cooled Engine under Flight Conditions. This Blade Is an Example of One Having a Low Uniform-Pitch of 5 Ft. but Turned Up to Higher Effective Pitch, ηP, To Afford Pitch Distribution. The Curves Were Obtained by Plotting Net Propulsive-Efficiency against Setting for Constant Values of *V/ND*



Aeronautics design No. 3792 and 9 ft. in diameter, is used on certain fighting planes when set 19 deg. at the 42-in. radius. The pitch at the tip is then 8.17 ft.; at the 36-in. radius it is 7.20 ft.; and at the 18-in. radius it is 5.78 ft. The need for such a pitch distribution means that the airflow around the hub and over the cylinders of the air-cooled engine causes the propeller to work in a non-uniform airflow. The engine is cooled better if the pitch is increased near the hub, but the net propulsive efficiency of the propeller is lowered if this is done. In other words, the propeller designer must compromise between cooling the engine and getting the best effective thrust for the airplane. This compromise is best effected by having the pitch distribution fit the airflow in such a way that an efficient angle of attack is maintained at each section. Experience and analysis of flight tests appear to be the best source of information. Complete data on Bureau of Aeronautics Blade-Design No. 4412, of 9-ft. diameter, are given in Fig. 4.

It is possible to fly almost any airplane in the Navy with any of four or five basic designs of blades by cutting off the tips to the correct diameter and setting the blades at a pitch that gives the required number of revolutions per minute. However, these methods rarely give the best fuel-consumption per mile; that is, the best propulsive efficiency. In the foregoing statement, the strength of the blades is not considered; it will be discussed later.

Actual Efficiency Below Test Efficiency

In the past, propeller efficiency has been adopted as a simple and practical criterion of the excellence of the propeller performance, and this is still true provided the proper definition of efficiency is used. It is wrong simply to place a propeller in a wind-tunnel, measure its efficiency under a given condition, and assume that the same efficiency is to be attained in a practical case with an actual airplane in flight. Certain propeller manufacturers have talked of the high efficiencies of their propellers, quoting tests showing 90-per cent efficiency; however, the true or net propulsive efficiency is usually lower than that measured in a wind-tunnel. As an example, assume that a propeller develops 800 lb. of thrust and, further, that the slipstream velocity creates 50 lb. of drag on the engine, fuselage and wings, this drag being caused solely by the difference between the drag at the speed of the airplane and the drag at the speed of the slipstream. Then there is only 750 lb. of useful thrust and, of course, the propulsive efficiency is correspondingly lower than that found on test in the free atmosphere of a wind-tunnel. As in ship-building parlance, it is the "propulsive efficiency" that counts; therefore, a given propeller arrangement should be judged entirely on that basis.

In attempting to analyze wind-tunnel data and actual flight-test data, a general conclusion can be reached that, with heavier-than-air tractor-propellers, about 2 to 3 per cent of the efficiency is lost as compared with wind-tunnel data. Fig. 3 is an efficiency chart showing the net propulsive efficiency as I have calculated it for a detachable blade widely used on the Navy fighting planes with radial air-cooled engines. It is to be noted that the method of plotting the curves in Fig. 3 is not the conventional method of η, or propulsive efficiency, versus V/ND; but η versus setting with curves of constant V/ND. This method offers itself more readily for office and field use. I believe that the waves in the curves are caused by blade distortion, together with changes in the inflow velocity.

Much more could be said about the propulsive efficiency of various arrangements of propellers and engines. It appears that a pusher propeller located astern of the trailing edge of the wings gives the best effective thrust from a propeller standpoint, but is not so good when the best locations of the principal weights, such as that of the engine, are considered. However, the present conventional tractor propeller ahead of the engine, on the nose of the airplane, has fairly good efficiency even if it is not the best. (See Fig. 3.) It appears that the propeller and the engine break the smooth flow of air about 3 ft. ahead of the propeller. The result is that the use of a small spinner usually produces no observed change in airspeed. The usual conventional type of spinner can be used or removed, so far as performance is concerned, for airplanes having a normal speed of about 150 m.p.h. or less. Commercial airplanes usually are fitted with a small propeller-spinner because it improves the looks and is a good selling point.

Substitute Propellers

Whenever the proper design of blade for a specific propeller is not available, airplanes can be kept in the air by using substitute propellers. These are made up by using blades of another design and of larger diameter that are kept on hand. These large blades can be cut down to the desired diameter, according to the diameter formula, and set to give the desired number of revolutions per minute. The general effect of substitute propellers is a loss of top speed of from 1 to 5 m.p.h.; climb and take-off may be slightly better or worse. In the diameter formula that follows, it should be noted that the number of revolutions per minute and the horsepower must be consistent for the type of engine on which the propeller is to be used.

$$D = K\sqrt[4]{\frac{\mathrm{HP}}{(\mathrm{RPM})^2 V}} \tag{4}$$

In equation (4), V is stated in miles per hour and represents airspeed. The value used should be 3 m.p.h. less than the top speed of the airplane when fitted with the correct propeller. The diameter in feet is represented by D, and K is taken as being 300 for a two-bladed and 285 for a three-bladed propeller. The number of revolutions per minute and the horsepower must be consistent for the type of engine on which the propeller is to be used.

For reasons of aerodynamic balance it is important that the same contour of tip be put on all the blades of the same propeller and that good balance be had before attempting to take the air. A template of thin metal can be used to form the tip on the first blade, and the other blades can be cut to conform with this template. The settings should be such as to give the number of revolutions per minute used in the formula. This is usually about 1 deg. less than the standard service-setting used for the correct propeller. If in doubt as to the initial setting for the first trial, the following formula should be used:

$$\tan\phi = \frac{4.37\,V}{\mathrm{RPM}} \tag{5}$$

In equation (5), ϕ is the setting angle at the 42-in. station and V is the normal high speed in miles per hour. After the first test, the setting can be varied

to give the exact desired number of revolutions per minute. A 1-deg. change of setting will produce a change of about 60 r.p.m. on direct-drive propellers.

Strength of Propellers

The strength of propellers is the great problem of the propeller designer. The increase of engine horsepower and engine speeds in the last few years has brought about a condition in which few of the larger engines can be fitted properly with a wooden propeller. The Liberty engine of 400 hp. at 1700 r.p.m. imposes a load that approximates the limit of capacity for a wooden propeller while leaving a sufficient factor of safety to meet service requirements. The result has been that the propeller designer was compelled to search for other materials.

On account of centrifugal force, the suitability of materials for aircraft propellers is largely dependent on a strength-density ratio in the cases where the blades are solid. It is an advantage to use thin airfoil-sections. The result is that the distribution of the material in the blade is often as important as the amount of material used. Virtually all the propellers now used in both the Army and the Navy are made of aluminum alloy known as 25S special, and sometimes called Standard Steel. They are of solid construction and of the detachable-blade type. The Navy at present is encouraging the development of a chromium-vanadium hollow-steel propeller. One experimental propeller of this type has lately been whirl-tested, and it has more rigidity than has the aluminum-alloy type. This construction will be almost necessary for the greater horsepowers, with which the bending moment caused by thrust is high; in the lower horsepowers it has the advantage of being cheaper, and it probably has longer life than the present type of aluminum-alloy blades.

With any material, the primary fiber-stresses are calculated by straightforward engineering methods taking into account the centrifugal forces, the bending moment caused by thrust, and torsion. These primary stresses vary proportionately to the square of the tip speeds for geometrically similar propellers of the same pitch. It is erroneous to copy an existing design of propeller blade and increase its angles without computing the new fiber-stress, because both thrust and torsion increase with increase of pitch. However, as increase of pitch requires more horsepower for the same number of revolutions per minute and for the same airspeed, an empirical formula can be built up which will give an approximate idea of the magnitude of the fiber stress involved in a given design. For the solid type of metal construction I have devised the following empirical formula, based on a large number of successful propellers of the detachable-blade type.

Empirical Formula for Maximum Fiber-Stress

$$f_t = \frac{(\mathrm{RPM})^2 (D)^2 \left(\frac{6D - r}{6D + r}\right)}{bt} \times \left[\frac{0.00048\,TB\rho}{t} + \left\{\frac{0.00000006\,(6D - r)\,\mathrm{HP}\left(\frac{1.4 - V}{500}\right)}{t}\right\}\right] \quad (6)$$

in which

f_t = Maximum fiber stress at r inches of radius, in pounds per square inch
RPM = Revolutions per minute
D = Diameter, in feet
r = Radius, in inches of section under consideration
b = Blade width in inches at radius r, using the unpitched plan form-width
t = Maximum thickness, in inches at radius r
ρ = Density of material, in pounds per cubic inch
T = Maximum blade-thickness, in inches at 42-in. radius
B = Blade width, in inches at 42-in. radius
HP = Horsepower per blade, or the total horsepower divided by the number of blades
V = Airspeed in miles per hour and equals zero for static conditions

Equation (6) does not apply very well to a solid one-piece blade made from a single forging from tip to tip, because this type of construction often suffers from fatigue failures caused by synchronized vibrations.

Metal Propellers

Aluminum alloy known as 25S special has the following physical properties:

Ultimate strength: 55,000 to 60,000 lb. per sq. in.
Yield point: 30,000 to 40,000 lb. per sq. in.
Fatigue strength: 12,500 lb. per sq. in. after heat-treatment and artificial aging
Elongation in 2 in.: 16 to 25 per cent
Brinell hardness: 90 to 125
Modulus of elasticity: 10,000,000 lb. per sq. in.
Density: 0.101 lb. per cu. in.
Specific gravity: 2.79

Grain structure depends mostly on the temperature of the metal as it is poured into the ingot and the rate of cooling the ingot. Ingots are water-cooled by a patented process in which means are provided for governing the rate of cooling, and are forged into billets. These are cropped to remove defects and to permit examinations of the grain structure, and are scalped to remove surface defects. They are then forged into propeller blanks. Heat-treating and artificial aging to give the required physical properties are done after the angles are placed on the propeller blank. Bending or twisting the propeller blades without special heat-treatment lowers the fatigue strength to about 11,000 lb. per sq. in. and, on designs that are close to this fiber stress, is likely to lead to fatigue failures in from 100 to 200 flying hours.

Calculation of Primary Stresses

The method of calculating the primary stresses in a propeller blade is to plot a curve of the intensity of centrifugal force for 25 per cent in excess of normal revolutions, at stations taken at each 6 in. of radius. The area under this curve equals the total centrifugal force, since centrifugal force equals (Mv^2/r). The curve of total centrifugal force, *CF*, is plotted against the length, or radius, of the blade starting with $CF = 0$ at the tip and maximum at the blade root. By dividing the total force at any radius by the cross-sectional area of the blade at that radius, the fiber stress caused by centrifugal force is obtained. The maximum-thrust curve of the blade is next plotted and, considering this as a load curve on a cantilever, the resulting bending moment is obtained. By the usual engineering method of MY/I the fiber stress due to thrust is found and is added algebraically to the fiber stress due to centrifugal force. If the moment of inertia I is taken about the minor axle of each section, a factor of safety is introduced, because the ellipsoid of stress of each section

turns about the blade as the radius is increased, so that the thrust does not always act along the minor axis. If the blade is of conventional design and is to run on an engine of not less than seven cylinders, and is of the type that is reasonably free from synchronized vibration, nothing else has to be done. However, if the plan form, type of tip, material or construction are changed, the stresses due to torsion and impulses of torque should be investigated.

It is to be noted that the designer of detachable-blade-type propellers does not take into account any deflection or restoring (that is, axial component after deflection) component of centrifugal force. In my experience, to consider that a component of thrust is counteracted by an axial component of centrifugal force is to neglect an exceedingly large torsion force that results if such a large deflection occurs. The net result is that, in metal, the fiber stress exceeds the fatigue limit. The metal blade should be designed to withstand all primary stresses without having the fiber stress exceed about nine-tenths of the fatigue strength of the material. The principle of dynamic rigidity does not seem to be useful in the design of solid aluminum-alloy blades.

The Whirl-Test for Strength

The Navy requires that all basically new designs be given a whirl-test of 100 per cent more than normal horsepower for a period of 10 hr. without any permanent deformation. During the test the blades are set in pitch with the normal service-setting. It is not sufficient that a design pass the whirl-test; it also should run reasonably smoothly and be free from flutter up to an overload of 25 per cent of horsepower. Flutter is a periodic change of pitch in the blade. Blades that suffer from synchronized vibration usually will flutter at a given number of revolutions per minute during a whirl-test, then run smoothly at some higher speed, only to flutter again violently at some still higher speed. For blades that begin to flutter at a certain number of revolutions per minute after about 5 hr. of test and flutter at all higher speeds, it is assumed that the fiber stresses are above the fatigue strength of the metal. Thus the actions of the blade during a whirl-test give important information regarding strength of design.

Necessity for Gearing a Propeller

Considerations as to the necessity for gearing an aircraft propeller are primarily divided into two classes; first, gearing to reduce tip speed; second, gearing to enable the propeller to give a higher thrust at low air-speeds such as will enable a plane to take off with a very heavy load and to have good efficiency at cruising speeds. At the present state of the art, high-power, high-speed engines should be fitted with geared propellers to reduce the high tip-speed that would result if direct drive were used. The amount of gearing should be such as to give a tip speed of about 800 ft. per sec. Gearing to a lower tip-speed than this usually gives no improvement in propulsive efficiency because the increase in diameter requires heavier propellers and increased length of the landing-gear. The result is that the theoretical gains in efficiency are lost. To illustrate this, let us assume that an engine of 600 hp. at 2100 r.p.m. is to be used in a new airplane. As a first assumption, let us try to use a two-bladed direct-drive propeller. Then we have:

$$\text{Diameter} = 305 \times \sqrt[4]{\frac{600}{(2100)^2 \times 130}} = 9.755 \text{ ft.} \qquad (7)$$

Consequently, we use a propeller 9 ft. 9 in. in diameter, and the tip speed will be 1072 ft. per sec. Since $V/ND = 0.558$, a probable net propulsive efficiency, considering the high tip-speed, of about 74.9 per cent can be expected.

Now consider the case if the engine is geared 3 to 2, which gives the propeller a speed of 1400 r.p.m. Then we have:

$$\text{Diameter} = 305 \sqrt[4]{\frac{600}{(1400)^2 \times 130}} = 11.949 \text{ ft.} \qquad (8)$$

A propeller 12 ft. in diameter is therefore used and the tip speed will be 879.6 ft. per sec. Since $V/ND = 0.681$, a probable net propulsive efficiency of about 78.6 can be expected.

Before a decision can be reached, it must be determined whether a propeller 12 ft. in diameter can be used. If ground clearance is insufficient, the landing-gear must be lowered, with its resultant increase in drag of the plane. If installed on a twin-engine type of plane, the 12-ft. propeller probably would require a re-spacing of engines which would result in practically a redesign and an increase of weight. If the landing-gear has to be lowered and the effect of the increase in drag is more than the 3.7-per cent gain in efficiency, then it is better not to gear.

Let us assume that the two-bladed 12-ft-diameter propeller is impractical; so, a three-bladed propeller will be tried. Direct drive for this would require a diameter of

$$D = 285 \times \sqrt[4]{\frac{600}{(2100)^2 \times 130}} = 9.115 \text{ ft.} \qquad (9)$$

Therefore a propeller 9 ft. in diameter would be used, and the tip speed would be 989.6 ft. per sec. Since $V/ND = 0.605$, a probable net propulsive efficiency of 74.5 can be expected. It should be noted that, for the same values of V/ND and the same tip-speeds, three-bladed propellers are about 2 per cent less efficient than two-bladed propellers.

The reduction in tip speed of this three-bladed propeller, compared with the two-bladed direct-drive, together with the increase in (V/ND), causes it to give approximately the same propulsive efficiency. In addition, the three-bladed type should give a better take-off in this case. Thus, this particular plane probably would be fitted with a three-bladed direct-drive propeller as the best engineering compromise.

There is no set rule about gearing; each case must be solved on its own merits. However, if gearing is resorted to, a reduction of tip speed below 800 ft. per sec. seldom pays in heavier-than-air types of craft. As engine horsepower and engine speeds are increased, gearing will become more and more prevalent.

Variable-Pitch Propellers

The subject of variable-pitch propellers the effective pitch of which can be changed while the airplane is in the air has interested aeronautical engineers ever since the basic principles of air propellers were understood. Numerous patents have been granted as a result of attempts to evolve a serviceable mechanism of this kind. The patents include ideas not only for changing the effective pitch but also for varying the diameter and the surface area of the blades. It must be understood that the variation of effective pitch provides only part of the possible theoretical increase in efficiency that can be realized; however, the mechanical difficulties in the way

of changing the diameter and area of the blade have so far prevented any encouragement in this matter. It seems that the ability to change the effective pitch of the blades offers the best field for development, and tremendous effort has been concentrated on this feature.

Advantages of Variable Pitch

The advantages of a variable-pitch propeller are as follows:

(1) *For Heavy Patrol Planes.*—A low pitch during take-off and a higher pitch during cruising could be used. Instead of cruising with the engine throttled, it seems better to let the engine operate at full throttle and to reduce the number of revolutions per minute by increasing the pitch. This case would fit exactly the service of air-mail planes, where the advantages of heavy-load take-off and of fuel economy at cruising speeds could be obtained with the same propeller.

(2) *For High-Altitude Fighting Planes Equipped with Supercharged Engines.*—With a conventional fixed-pitch propeller, it is impossible to make use of the full power of the supercharged engine at any great altitude without using an excessively high number of revolutions per minute. The practice of taking off and climbing to about 6000-ft. altitude with the engine partly throttled is the only partial solution of the problem when a fixed-pitch propeller is used.

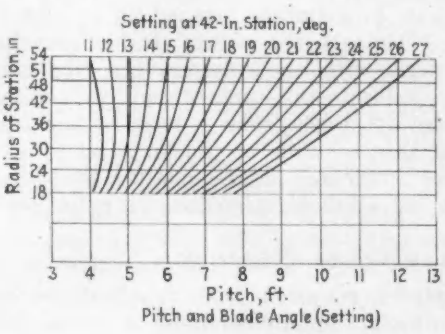
(3) *To Reduce the Length of Run after Landing.*—In the case of complete reversal, the negative thrust could be used to act as a brake after landing; however, I believe that the installation of mechanical wheel-brakes promises to eliminate the necessity for this feature.

Some fairly successful variable-pitch propellers are now available, but the development is not such as to make them of general service use. The difficulties are, primarily, that in the higher horsepowers, say above about 185 hp., the propellers become very "rough" after about 40 to 50 flying hours. The high value of the centrifugal force on each blade under a normal number of revolutions per minute presents a bearing problem rather than an actuating-mechanism problem. Simply to take on a 4-in-diameter roller-bearing or ball-bearing the total centrifugal-force load, which is about 50,000 lb., places such a load on the pitch-actuating mechanism that the small parts wear sufficiently within a short time so that both blades do not have the same effective pitch. This inaccuracy causes a difference in thrust between the blades that results in violent vibrations.

In Europe, a type of variable-pitch propeller that uses oil pressure to counteract the bearing load has met with some success in the lower horsepowers; and at present the Navy is experimenting with a type that counteracts the bearing load with the hydrostatic pressure produced by a revolving column of mercury.

In the high-speed fighting-type or airplane, the weight of the variable-pitch propeller is important because, beyond a certain weight, better results could be obtained by putting the extra weight into a larger and more powerful engine and using a fixed-pitch propeller. Such a high restriction as to weight of the propeller does not apply equally to the large heavy patrol plane; the propeller is such a small percentage of the total load that climb and take-off are not so much affected.

It is hoped that, within the next two or three years, a really serviceable type of variable-pitch propeller will be developed. This will necessitate a change in the present technique of propeller design so that changes of effective pitch will not produce erratic propulsive efficiencies. Hence, the interesting art of aircraft-propeller design is ever changing to meet new conditions.



Blade Design

	18-In. Station	24-In. Station	30-In. Station	36-In. Station	42-In. Station	48-In. Station	51-In. Station	54-In. Station Tip
b-Blade Width, in.	7.12	7.25	7.07	6.45	5.42	4.05	3.31	0
t-Blade Thickness, in.	1.08	0.86	0.69	0.56	0.40	0.26	0.18	0
C.R t/b	0.1516	0.1186	0.0975	0.0868	0.0738	0.0641	0.0544	
R, per cent	33.3	44.4	55.5	66.6	77.8	88.9	94.4	100.0
Φ-Design Angle, deg.	32.3	27.8	24.4	21.8	19.9	18.3	17.6	
P-Design Pitch, ft.	5.96 (19.9 Deg. at 42-In. Sta.)	6.63	7.13	7.54	7.96	8.31	8.47	

Blade was drawn turned up 6.9 Deg. from uniform pitch of 13 Deg. at 42-In Station

NOTES

Compared to flight of some other 9-ft. blades the values of C_p and C_t appear low but flight test blades had higher C.R. and different pitch distribution

$$S.Hp. = C_p \rho n^3 D^5 = \text{ft-lb. per sec.}$$
$$= C_p\, 1.995 \times 10^{-11} (R.p.m.)^3 D^5 = \text{Horsepower at sea level}$$

$$\text{Thrust} = C_t \rho n^2 D^4 = Lb.$$
$$= C_t\, 6.583 \times 10^{-7} (R.p.m.)^2 D^5 = Lb. \quad \text{Thrust at sea level}$$

$$\eta = \frac{T.Hp.}{S.Hp.} = \text{Thrust Efficiency} = \frac{C_t}{C_p} \times \frac{v}{nD} = \frac{C_t}{C_p} \times \frac{88V}{ND}$$

V = M.P.H.
N = R.P.M.
D = Ft.
n = R.P.S.
v = F.P.S.

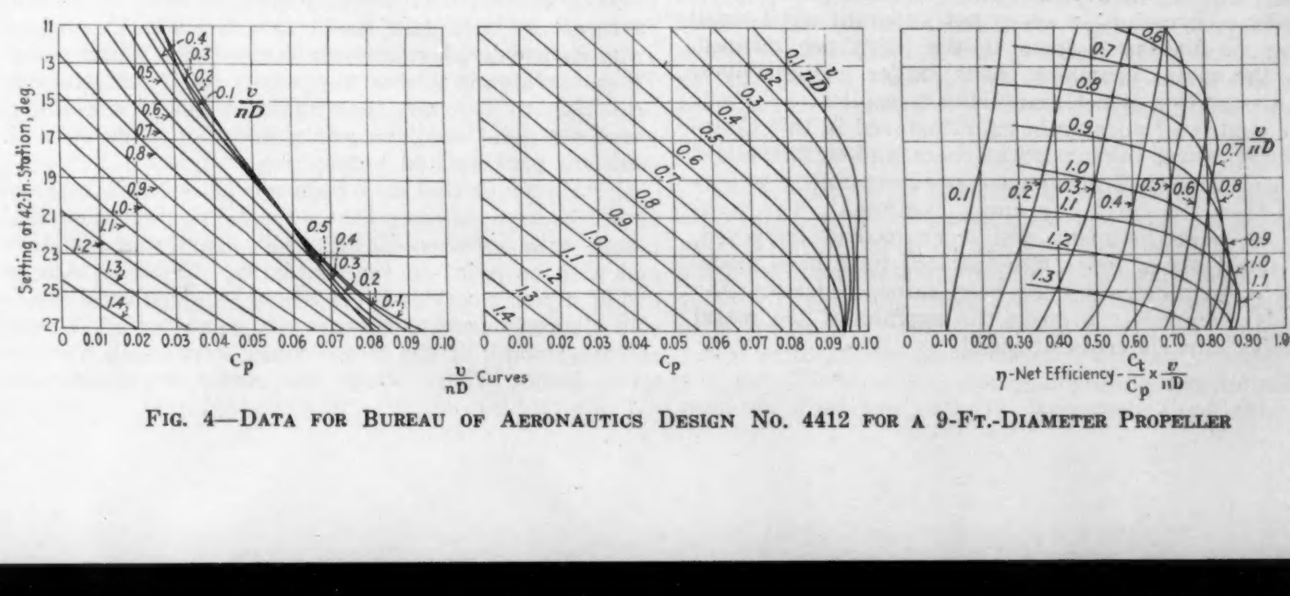


Fig. 4—Data for Bureau of Aeronautics Design No. 4412 for a 9-Ft.-Diameter Propeller

Prevention of Corrosion in Duralumin Airplane Structures

By LIEUT.-COM. L. B. RICHARDSON, U. S. N.[1] LOS ANGELES AERONAUTIC MEETING PAPER

AT first believed immune, aluminum alloys have been found extremely susceptible to both surface corrosion and intercrystalline corrosion. The latter goes on under paint that has been applied to imperfectly cleaned surfaces, and shows only as blisters. Because of this, it has become commonplace to break with the fingers the ribs and the trailing edges of duralumin lower wings and tail-surfaces.

Contact of duralumin with brass or steel hastens corrosion, and protective paint coverings are dissolved by dope where fabric surfaces meet metal parts.

All-duralumin structures are not considered suitable for sea-going aircraft unless all joints and seams are of water-tight construction, not only in hulls but in other members of the structure. Corrosion over the land is much less severe.

Few manufacturers seem awake to the importance of corrosion. The fight to avoid it should begin with avoiding seams that are difficult to protect and hollow members that cannot be sealed hermetically.

Service precautions recommended include greasing at points that are hard to clean, a thorough washing with fresh water after each flight, and the same precautions in making repairs as in the original building of the airplane.

In the discussion mention is made of C. W. Hall's seaplane, protected only by grease, and various reports are given of European experience with corrosion. It is stated that the duralumin hulls of the flying-boats that received such severe treatment during the attempted Rogers flight to Hawaii emerged virtually uninjured, while the all-metal planes used in a recent flight from England to Australia stopped for extensive overhauling necessitated by corrosion.

A thrilling experience with fire in the air, which demonstrated the increased safety secured by metal construction, is related by one discusser.

STRONG alloys of aluminum were believed, not many years ago, to be very resistant to corrosion. Airplanes, and even seaplanes, were constructed on the assumption that aluminum alloys required almost no protection, or at least that they required less protection than did steel.

Costly experience has shown that these alloys are extremely susceptible to corrosion, and that the corrosion occurs not only on the surface of the metal, but also along the boundaries of the crystals—the "intercrystalline corrosion" that has now become well known and dreaded because of its embrittling effect on the metal.

In the early seaplanes in which these alloys were incorporated, the results of corrosion were so destructive that grave doubts were raised in many quarters that the use of the alloys was justified at all; and it is true that many aviators are skeptical still as to their serviceability in seaplanes. It seems to be a characteristic of duralumin that it corrodes and disintegrates under a paint film applied after cleaning the metal by ordinary means. The disintegration, which is an effect of intercrystalline corrosion, is often not apparent until small blisters or discolored spots in the paint are scraped, when the metal crumbles easily under a light blow. Such a condition is not reassuring to a pilot.

The quality of duralumin manufactured in this Country has improved during recent years, and certain alloys have been developed that have less susceptibility to corrosion than the early duralumin exhibited. The technique of heat-treatment and working has improved. Extensive tests of protective coatings have been made, and definite information has been gained regarding the methods required to prepare the surface of the metal to receive durable coats of paint.

In spite of the progress that undisputedly has been made, however, aluminum alloys in seaplanes still present about the severest maintenance problem met anywhere by those who use metals, except possibly in salt-refining works. Very recently we have seen duralumin members, less than three months out of one of our best-known airplane factories and covered with an excellent-appearing varnish paint when new, that now show numerous blisters ½ in. in diameter, pushed up by aluminum oxide forming beneath the paint. It has become commonplace to break with one's fingers the ribs and trailing edges of duralumin tail-surface and lower-wing frames of seaplanes after less than a year of service. This brittleness of thin sections of the metal after exposure to corrosive influences is the quality that disturbs us when we see all-metal airplanes entering service.

EXAMPLES OF CORROSION

We have seen plates, removed from the bottoms of year-old duralumin hulls, so badly corroded at joints and areas of contact with wood or steel, or even with other surfaces of duralumin itself, that the edges crumbled away as powder, leaving only paper-thick sound metal. These duralumin plates supposedly were heat-treated properly, but evidently their surfaces were not well prepared for paint, and the joints were not made up with sufficient packing and paint.

Certain wings that have been overhauled at San Diego have ribs of duralumin that were fabricated in several pieces, with crevices ideal for the collection of moisture and with no paint on the contacting surfaces. At the end of a year's service these wings required very extensive rib replacements because of crumbling of the duralumin; many of the lower wings were ready for the scrap heap. These wings also suffered considerably

[1] Naval Air Station, San Diego, Calif.

from two other causes of corrosion: around each piece of brass or copper, such as screws and trailing-edge caps, a hole was found corroded entirely through the duralumin; and along those parts of the wings that had been in contact with the doped fabric the paint was entirely dissolved, and blistering corrosion had begun in many places.

A number of seaplanes were constructed with aluminum alloy in cockpit floors, control-pulley supports, and similar locations. At the end of 18 months' service, corrosion had made holes entirely through these structures in many places, and the metal had reached such a condition that it was ready to fall apart under any considerable stress.

This corrosion of duralumin in seaplanes and amphibians is a startling phenomenon. In land airplanes corrosion is not nearly so rapid, but it is a serious problem nevertheless. Duralumin will corrode rapidly in the presence of moisture, even though it be not salt moisture. Of course, the development of dangerous corrosion in landplanes will require a long period, compared with the amazingly rapid deterioration of the metal in seaplanes; however, it is absolutely essential that the best available principles and practice be followed in the original protection and in field and shop maintenance of duralumin airplane structures if they are to operate safely for the long service lives that should be expected if the duralumin is treated as intelligence and experience dictate.

Few Manufacturers Awake to Corrosion

The questions of aluminum-alloy structures versus steel, wood, or steel and wood, are without the scope of this paper. There is an indisputable field of usefulness for aluminum alloys in the primary structures of airplanes of all classes. It behooves the industry to develop designs which will utilize duralumin in shapes and assemblies that lend themselves readily to protection and maintenance, and to construct airplanes with the utmost care and attention to every detail of protection. It is believed that very few airplane manufacturers yet realize the seriousness of this problem. Those who have been building airplanes for the Navy for several years have had it impressed upon them, and some of them have shown the results by their serious attempts at correct protection.

Unfortunately, the good reputation for corrosion-resisting that was first given duralumin has persisted in the minds of many, and only those who have seen the havoc wrought by sea water have been completely converted. It is impossible to emphasize too strongly the extreme necessity for proper structural design and thorough attention to every detail of protection on the part of the manufacturers. Maintenance is impracticable, for example, if the fuselage structure presents dozens of inaccessible metal surfaces, if wing spars and ribs consist of series of pockets to collect and hold water, or if duralumin members are secured to steel fittings or to wooden frames with no paint in the joints.

What steps, then, must be taken in the construction of the airplane to afford a reasonable chance of successful maintenance?

The first steps are taken in the drafting room. One of the most fruitful causes of duralumin corrosion is the design of structures abounding in seams, pockets, crevices, open-ended tubes, and similar moisture-catching and holding features. The aim of the designer should be to have every hollow member of the structure hermetically sealed, and to avoid tubular members with end fittings that permit ingress of moisture but do not permit protection and inspection of the interiors.

The highly detrimental effects of placing dissimilar metals in physical or electrolytic contact with duralumin must be guarded against in design and construction. Copper and its alloys are particularly bad in their corrosive action on duralumin and should be avoided entirely in proximity to it. Even steel has the same detrimental effect on duralumin, though to a less degree. Steel often is incorporated in those members of the airplane subjected to the greatest tensile stresses, and for this reason contact between duralumin and steel cannot always be avoided. Scrupulous care should be insisted upon to assure that the steel is cadmium or zinc-plated, and that both metals are painted thoroughly before assembly. Whenever stress conditions permit, insulating material, such as paint-impregnated fabric, should be placed between the steel and duralumin surfaces.

Moisture softens and accelerates the break-down of paint coatings and causes corrosion. Provision should be made by the designer for ample draining and airing facilities. To facilitate drying, plentiful drain-holes and hand-holes are required, not only in hulls and floats, but in any other place where moisture might collect either from outside sources or from condensation, as inside all-duralumin wings and other surfaces. Every effort must be made by the operating personnel to keep duralumin structures dry.

The designer should take into consideration also the nature of the service for which the airplane is intended. For example, the all-duralumin airplane as now constructed in this Country is considered entirely unsuitable for seaplane service. Salt-water would lodge at the trailing edges of all surfaces and along the bottom seams and joints of the fuselage and wings, in spite of all the drain holes that could be provided. Frequent, at least annual, removal of the entire lower skin of the fuselage and surfaces would be essential to the safety and long life of the airplane. The only serviceable type of all-duralumin construction for seaplanes is believed to be that employing watertight joints and seams throughout, even to the wings and tail surfaces. Unless the all-watertight construction is adopted, it is believed preferable to adhere to fabric covering for all possible parts of the seaplane.

Certain alloys are known to be the least susceptible to corrosion, and their adoption is essential. Having selected the best alloy, it must be heat-treated and quenched in cold water, as hot-water quenching reduces corrosion resistance. It has been the bad practice of some plants to use duralumin without heat-treating where the strength of the quenched metal was not required. In such cases pure aluminum should be used, as it is more resistant to corrosion than is duralumin.

Careful Cleaning Essential Before Painting

The length of service life of a duralumin airplane structure depends as much on the shop that prepares the surface for paint as on the engineer, builder, or pilot. Duralumin surfaces are difficult to prepare properly for paint. Various processes are available: sand-blasting, scratch-brushing, etching with caustic solution and nitric acid, anodic oxidation, the Jirotka process, and the metallic-aluminum spray. The ordinary methods used on steel are entirely inadequate, and this fact

probably accounts for some of the corrosion that has developed so early in the life of duralumin structures in the past.

Having cleaned the metal of all grease and roughened the surface slightly to secure good paint-adhesion, each part, no matter how minute, must be coated on all sides. This means that all details of the various sub-assemblies and assemblies must be painted prior to assembly, and this pre-assembly coat must be allowed to dry. It is impossible to exaggerate the importance of a complete paint-coating, even on the most minute washer and clip. Corrosion which starts between an unpainted washer and a duralumin fitting often leads directly and promptly to a large spot of loosened paint and the beginning of trouble.

The choice of paint is very important, and should be made with consideration for the kind of service the airplane is expected to enter and the relative degrees of exposure of the various parts of the plane. Varnishes and lacquers may be satisfactory as protection for duralumin in land airplanes in dry climates, although these paints require very careful and frequent inspection and retouching to guard against blistering. Pigmented varnishes are somewhat better, but they do not stand up well for much longer than six months. None of the varnish paints have proved satisfactory for portions of the plane where the conditions are severe and inspection is difficult.

Experience has shown that bituminous paint is an excellent protective coating for duralumin in locations where it is not subject to abrasion or to the direct rays of the sun; in short, it is valuable for the coating of interior surfaces. It has been found highly satisfactory on such parts of the structure as fuselage frames, the interiors of duralumin floats, and on wing and tail-surface frames. This paint is especially effective when pigmented with aluminum powder. It has excellent adhering qualities, comparing favorably with baked enamels in this respect. A priming coat of red lead or a paint containing iron oxide and zinc chromate, followed by an enamel, baked on whenever possible, furnishes the best protection so far developed for exterior metal surfaces where bituminous paint is unserviceable because of its poor resistance to abrasion and light.

Service To Reduce Corrosion

It might seem that an airplane built with so much attention to preservation should require almost no maintenance attention, but such is not the case. Continuous care is required to prevent breakdown of the protective paint-coatings, and an effort should be made to overdo the means adopted to prevent corrosion.

Prior to placing a duralumin airplane structure in service, it should be examined carefully to determine what portions, such as joints or recesses, will be difficult to keep free from moisture or from corrosion products. These portions should be coated with heavy grease and kept coated until the airplane is ready for a shop overhaul.

Seaplanes should be washed with fresh water after each day's operation, and dried with compressed air. Interiors of both seaplanes and landplanes should be opened for draining, drying, and airing at all times when standing. Seaplane structures should be inspected daily and landplanes at short intervals, depending on the nature of the service, the humidity and proximity to the ocean. Every defective spot in the paint coating must be attacked as soon as found, cleaned down to bright metal, roughened, and repainted.

Dirt and sand should not be allowed to accumulate inside the fuselages of duralumin airplanes, as they will attract moisture and hold it in contact with the metal. This is particularly to be guarded against in those localities where the dirt of airdromes contains chlorides or alkalis; the effect of an accumulation of such dirt moistened by rain or condensation is almost as bad as seaplane service.

If minor repairs are made to the duralumin structure of an airplane, the practices outlined in the foregoing should be followed in matters affecting liability to corrosion. For example, metal used in repairs must be either duralumin or plated steel, well set in paint. Copper or brass rivets or screws must be avoided; even iron or steel rivets, screws, and bolts are inadvisable.

Frequency of Overhauling Seaplanes

The questions of proper frequency and extent of major overhauls of duralumin airplanes are as yet unsettled, and one can offer only opinions based on observation of the condition of duralumin members that have been in service under the diverse conditions met by Naval airplanes of the various types: seaplanes, amphibians, landplanes, and convertible planes which have operated alternately on floats and on wheels. It is obvious that seaplanes and amphibians must have major overhauls frequently, for even with the best of maintenance the protective coatings will suffer a general deterioration in a comparatively short time, and general corrosion must inevitably follow. Experience thus far indicates that duralumin seaplanes of all-watertight construction should be overhauled at intervals of not more than 15 months. Seaplanes and amphibians of which the major assemblies are fabric-covered duralumin frames should be overhauled annually, or more frequently if extensive incipient corrosion is found at any time after six months in service.

The major overhaul of an all-duralumin seaplane of watertight construction presents no difficulty and is not an expensive process. It inevitably involves replacement of a large number of corroded rivets and patching of corroded spots in the structure, chiefly in the interior. No all-duralumin seaplane of non-watertight fuselage and wing construction would be likely to be worth overhauling after a year's service.

The duralumin-framed and fabric-covered seaplane should receive an overhaul involving removal of a large part of the paint on the principal structural members. This can be done most efficiently and conveniently by a low-pressure sand-blast, at about 15 lb. per sq. in., using No. 60 or finer grit. The sand-blasting, being an ideal preparation for the new coats of paint, must be followed immediately by the priming coat. A number of replacements of corroded members will be required, depending on whether the members were hermetically sealed and whether access was possible to all surfaces not sealed.

Amphibians require the same nature of overhaul as seaplanes. If planes of this type were constructed with all-duralumin hulls or floats, instead of wooden frames under duralumin shells, their overhauls would be little more costly than overhauls of other metal hulls of equal size.

The question of the extent and frequency of overhaul of landplanes is considerably different. If the airplane

was designed and constructed with careful attention to the preservation of the duralumin, and if maintenance in the field has been thorough, all-duralumin land airplanes should need overhauling very rarely. The principal fittings and connections should be dismantled at fairly frequent intervals—say after each 600 hr. of flight—to detect and repair elongated holes, either worn or stretched out-of-round. Present-day engineers, with few exceptions, have been unduly optimistic as to the allowable bearing strengths of metals. As a result, the principal highly stressed connections, such as wing hinges, strut connections, landing-gear and engine-mounting attachments, frequently have been designed with too little bearing area for the bolts and pins. They require careful inspection, especially after the first few hundred hours of flight. Normal wear elongates many of these holes. Minor mishaps like a sharp ground-loop, an unusually severe landing or "hooking a wing," introduce stresses for which the load factors should provide but to which they seem unequal at the fittings, strut connections and wire lugs.

Such parts should be provided with bushings that can be renewed when a hole elongates, and the principal lugs and fittings should be designed with sufficient metal around the bolt holes to allow reaming and bushing of elongated holes. This recommendation applies to both duralumin and steel parts, as we find many elongations in both. It is true that the additional metal thus provided adds slightly to the weight, but it eliminates the costly operation of cutting out and replacing a lug or fitting in which a hole is elongated enough to cause an objectionable amount of play but not enough to warrant rejection because of reduced strength.

Aluminum-Alloy Castings Last Well

In connection with the subject of bearing areas for bolts in duralumin airplanes, it is interesting to note that virtually no elongated holes are found in the heat-treated aluminum-alloy castings that have been incorporated in large numbers in airplanes of many types. This is due in most cases to the fact that generous margins of safety are provided in these castings to compensate for the possibility of flaws and non-uniformity in thin sections. Also, it is far easier and cheaper to allow generous bearing-areas in a cast fitting than in one built up of rolled or drawn stock. This feature of the strong-alloy castings should encourage their still more extensive adoption. It is noteworhty also that these heat-treated castings apparently offer more resistance to corrosion than do rolled and drawn aluminum-alloys. The reason for this is not clear, but that it is a fact has been proved by several years' experience.

Mention should be made of Alclad aluminum alloy. This material consists of duralumin on which a thin external coating of aluminum of very pure grade has been rolled. It is now available in sheet form, and eventually will be available in tubing, coated both inside and outside. This material is very promising as a substitute for duralumin, as the pure aluminum has the dual advantages of offering somewhat greater corrosion resistance than duralumin and of protecting the duralumin by electrolytic action, the aluminum being attacked. Alclad has the slight disadvantages of increased cost and decreased strength (both about 10 per cent), but these are inconsequential in comparison with the boon offered to the industry by the material. Alclad should be incorporated in airplanes in all places where severe corrosion conditions will be encountered, which means throughout the entire structures of seagoing airplanes and in all duralumin parts 1/16 in. or less in thickness in land airplanes. It is especially important that all tubular members be made of Alclad alloy.

If this new material proves to be as effective as is at present indicated, it is believed that it will be the means of "selling" aluminum alloys to the operating personnel of aviation. This will involve a considerable revision of the opinion held today. However, it cannot be too strongly emphasized that, even though Alclad is adopted, airplane structures must still be designed, protected and maintained with all the care recommended in this paper for ordinary duralumin. Its introduction is a great stride toward satisfactory duralumin structures, but we must not deceive ourselves by thinking that we can reach the goal of non-corrodibility in one step, however great.

THE DISCUSSION

Chairman E. E. Wilson[2]:—It must be a surprise to most of us who are familiar with landplane operation and large metal construction, in which this is no problem whatever, to realize the extent to which this corrosion occurs and the seriousness of its nature.

Edward P. Warner[3]:—Does Commander Richardson know any explanation for the apparent difference between our experience here with duralumin and that in certain European countries; is it due to difference in fabrication or material? Airplanes and seaplanes are, I think, kept longer in continuous service in some parts of Europe, and they appear to have very little corrosion trouble.

Lieut.-Com. L. B. Richardson:—I do not know, but I have an idea that it is a combination of reasons. I do not know how efficient they are in painting their structures or in preparation for painting. I do know that the methods used in this Country so far do not protect the material.

Chairman Wilson:—Secretary Warner asked that question for the benefit of others, as he is familiar with the difference of opinion that exists. Charles Ward Hall has maintained a flying-boat in Long Island Sound protected only by a film of grease. The disadvantage is that clothes get dirty in working around such an airplane; but Mr. Hall has demonstrated that reasonable protection can be had in this way. Without this protection it is very necessary, as Commander Richardson says, to resort to other means. Our amphibians and seaplanes are washed down with fresh water the moment they come in, and all corrosion is removed.

The greatest problem in the Navy is the space in which we have to operate. The Langley has a flying deck about 500 ft. long, and we operated as many as 32

[2] S.M.S.A.E.—Chief of Staff to commander, Aircraft Squadrons, Battle Fleet, U. S. S. Langley.

[3] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, Navy Department, City of Washington.

planes simultaneously from its flight deck, parking 31 of them forward of the barrier and landing the last one. Because it is necessary that airplanes for our use be made as small as possible, light alloys are very attractive to us and are being utilized, inasmuch as we expect the development in them to go ahead. Where light alloys can be used to the greatest advantage is also where the greatest difficulties are encountered in their use.

A. E. RAYMOND[4]:—I understand that the Aluminum Co. of America has an aluminum alloy possessing physical properties about 15 per cent higher than those of ordinary duralumin, which has not been put on the market yet because it is not as resistant to corrosion as are other alloys, and that the company intends to cover this material with a 10-per cent coat of aluminum, making its corrosion resistance the same as Alclad and keeping the weight-strength ratio up to that of duralumin.

COMMANDER E. M. PACE, JR.[5]:—We bought one flying-boat abroad that had a protective coating like a varnish. Exposure tests show that various coatings are effective, as long as they last, in protecting the material. The object of the most recent tests has been to determine which coating will last the longest. Mr. Hall's grease coating is good as long as it is intact, but it is a question how long it will last under tropical conditions in sunlight and salt air. I recall a report that the cost of overhauling a number of boats in the Baltic, after one year's service, was 30 per cent of their original cost to the customer.

Is Corrosion Less in Europe?

SECRETARY WARNER:—I have no idea that there is any inherent superiority in either design or maintenance in one country compared with another, but one hears less and sees less evidence of corrosion in Europe than we are accustomed to see and hear here. In the Baltic I saw the boats to which reference has been made. They had been operating for six months and were coated with a paint which is renewed from time to time, and they showed no signs of corrosion after that period. I do not know about the overhaul cost or how much work was done. I can only proceed by inference from the fact that corrosion does not seem to cause the alarm in Europe that it does here. Commander Richardson may know about minor differences in the alloys used.

COMMANDER RICHARDSON:—We have used different alloys ourselves. An inferior grade corroded in about 75 per cent of the time that the one we now use does. Naval constructors have nearly standardized on the alloy known as 17ST, which is the most resistant alloy of which we know.

J. N. KINDELBERGER[6]:—I talked with Major Mosley after his return from an inspection trip in Europe in the spring of 1918, during which he spent most of his time talking with the mechanics and maintenance men, and his observations were that they have just as much trouble as we are having in this Country, if not more. He said that it was customary to shake out a pint of rivets once a month from the all-metal riveted planes, and they were not nearly so careful or successful as we have been in this Country in the protective coatings.

A VISITOR:—It may be interesting, as an example of the conditions that exist in these planes after they have been in service for a considerable time, to recall the John Rogers attempt. The planes used had been in service I think about a year before the attempted Hawaiian flight. One of the planes, Lieutenant Snodley flying, came down in the night about 300 miles at set with a full load and both engines dead. This was perhaps a more severe test than could be given to them in any other way. They hit so hard that the gasoline tanks were elongated, but no gasoline leaked; the bottom of the frame was bulged in, but there were no leaks at the rivets. The plane was towed in 300 miles by sea, and the entire structure was in surprisingly good condition. Commander Rogers came down near the Hawaiian Islands, and the plane was in the water for about 10 days, I think; yet it showed no ill effects, so far as I know. It was repaired at Hawaii and it flew again immediately.

S. A. MCCLELLAN[7]:—Secretary Warner's question can be answered from the recent flight of the short all-metal boats from England to Australia. After reaching India they stopped at the new naval base at Singapore for four weeks, during which time, I am told by Commander Steadman, of the Royal Canadian Air Force, approximately 60 per cent of the overhauling was on the hulls; it was not structural repair, but was due to corrosion.

COMMANDER RICHARDSON:—The hulls of all the PN-9 flying-boats are water-tight. The wings are made of wood, covered with fabric.

Less Corrosion over the Land

GEORGE PRUDDEN[8]:—We have met no such severe conditions for metal planes in the operation of land airplanes. We have been operating them for eight years, giving them severe strain under all conditions, and have not met such severe corrosion nor seen that rivets have fallen out. However, we recognize the danger of corrosion and are very careful in the construction of planes, using Navy specifications all the way through.

I have had opportunity to observe the effect of salt water at various distances in from the sea. A spray that blows off the surface of the water seems to have a very rapid corroding effect on all metals, regardless of what they are, but it seems to disappear within a distance that can be measured in hundreds of feet. I have been at the Navy base frequently and have seen something of what Commander Richardson has to meet. In our operation in the interior with Ford airplanes, with which I have had virtually all of my contact in the operation of metal airplanes, we have found no difficulty from corrosion. We realize that duralumin does corrode, and we meet and provide against corrosion.

As a definite example of the safety of metal construction, the first Ford airplane protected the lives of Secretary Warner and myself and a few others during a trip from Dayton to Detroit. Half-way between the cities we suddenly detected a very strong odor of gasoline. We looked for the leak but could not find it. Flames came out under the hood as we nosed down, and the pilot was close to the engine in that old design. I was sitting back of the pilot and Mr. Stout was behind me. Mr. Warner was in the front of the cabin, typewriting, and there were 10 men in the airplane. Eddie Hamil-

[4] Assistant chief engineer, Douglas Co., Santa Monica, Calif.

[5] Construction Corps, U. S. N., inspector, Douglas Co., Santa Monica, Calif.

[6] Chief engineer, Douglas Co., Santa Monica, Calif.

[7] Sales engineer, Pratt & Whitney Aircraft Co., Hartford, Conn.

[8] Managing director, Prudden Aircraft Corp., San Diego, Calif.

ton, who was flying the ship, side-slipped 1000 ft. in one direction and then the other, to put out the fire. He succeeded, but by that time we were headed for a church steeple, and barely missed that and another building before we struck and went through two rail fences and across a road, landing in a pigsty. Two chickens suffered the only fatalities. We owe our lives to the metal airplane.

We are working very seriously to make a metal plane that really will be safe.

LEIGH M. GRIFFITH[9]:—Referring to the failures at the rivets, I should like to ask whether this was traceable to excessive stress or vibration. Did the worst corrosion occur at points subject to high stress or severe vibration?

COMMANDER RICHARDSON:—It seems to have no association with the vibration or stresses and to be purely a question of exposure, assuming the same quality of metal.

CHAIRMAN WILSON:—At one time calcium chloride was being used on the airship Los Angeles and was spilled accidentally on the duralumin members. Later, corrosion was discovered, and it was necessary to replace the parts that had been damaged thus. In working on the landing-field, it was necessary to avoid the use of calcium chlodide on this account. This is an indication of the precautions that have to be taken in the use of the material.

[9] M.S.A.E.—Vice-president and general manager, Emsco Aero Engine Co., Bell, Calif.

Germany's Airline Development

THERE are 76 regular airlines in Germany, both local and international. They are controlled by the Deutsche Lufthansa, or by companies affiliated with it. Under this administration they have maintained a very high record of both efficiency and safety.

The total distance flown by the D.L.H. airlines during 1926 was 3,816,000 miles. In that year these companies carried a total of 56,268 passengers; 1,418,000 lb. of freight; 660,000 lb. of mail and newspapers.

On all the 76 lines there is at least one airplane a day in each direction, except on Sundays. About 81 towns in Germany have regular connections by airline. The most important airdromes are located at Berlin and Cologne.

The German air companies receive a very large appropriation for carrying mail, paid by the Postmaster General and by certain German towns. The sum, about $6,500,000 in 1927, covers about 70 per cent of the total expense for cost of operation and maintenance, while only about 30 per cent of those expenses is covered by freight and passenger fares.

It is interesting to note that the D.L.H. charges from $0.75 to $1.00 per mile for air taxis according to the type of plane used. Passenger fares are about the same as the first-class fares of express trains.

The company is steadily increasing the winter operation of its lines. In 1927 only about 40 per cent of the summer lines was maintained during the winter; this year 45.7 per cent of the summer mileage was continued in the winter months.

Only two airlines in Germany are lighted sufficiently for night flying—Berlin to Koenigsberg and Berlin to Hanover.

It is reported that within the next 2 years a regular service will be established between Berlin, Moscow and Peking. The usual informatory flight over that route has already been accomplished by two planes, and negotiations with the governments concerned are now progressing. The Berlin-Peking route represents one of the longest railroad journeys in the world, and thus affords an ideal demonstration of time saved by airplanes over long distances. The railroad time is 12 days but, due to the hardships of traveling through less civilized countries, many travelers prefer the sea voyage, which takes at least 40 days. The first flight by regular commercial airplanes required only 70 flying hours.

In aeronautics, however, Germany, is associated in the popular mind chiefly with Zeppelins, and the credit for airship development must be given to that country. The far-reaching Zeppelin organization today is still endeavoring to carry out Count Zeppelin's ideas of a worldwide network of airship lines. The airship, at present, appears to represent the only practical means of long overseas flight.—Daniel Guggenheim Fund for the Promotion of Aeronautics.

International Freight-Container System Proposed

AN extension of the container system of goods transport, with a view to reducing packing and warehousing expenses and expediting the delivery of traffic, was suggested to the World Motor Transport Congress at Rome by Signor Crespi, president of the Banca Commerciale Italiana and a director of a number of important Italian undertakings.

Briefly stated, Signor Crespi's proposal is that a powerful international organization, somewhat on the same lines as the International Sleeping Car Co., should be created and should be granted the necessary facilities to introduce in all countries standardized railway-trucks and road motor-vehicles specially constructed for the carriage of containers. As a preliminary to this step, he suggests that there should be set up an international commission to investigate and report upon the possibilities of the scheme, toward the cost of which he offered, on behalf of the Royal Italian Automobile Club, a sum of $5,000.

At a subsequent meeting of the Congress a resolution was passed to the effect that

> The World Motor Transport Congress at Rome requests the presidents of the International Chamber of Commerce, the Commission of Communication and Transit of the League of Nations, the International Union of Railways, the International Association of Automobile Clubs, the Permanent International Bureau of Motor-Car Manufacturers, and the International Association of Tourism, to appoint an international commission to study the possibilities of the project outlined by Signor Crespi.

—*Modern Transport.*

Standardization in the Automobile and in the Aeronautic Industry

By C. F. Clarkson[1]

Los Angeles Aeronautic Meeting Paper | *Illustrated with* Charts

> **The eliminating of immateral and economically harmful detail differences in construction and the establishing of sound material and dimensional specifications is vitally necessary. Thus design and product can be improved, cost reduced, time saved, and maintenance facilitated.**
>
> **Standardization facilitates the making of needed changes economically. Without standardized product, the machine-tool is virtually valueless.**
>
> **No industry has been more active, or produced more standards, than has the automobile industry.**
>
> **It was largely due to the adoption of this standardizing policy, and joint engineering work on the part of leading producing companies, that the American car achieved the necessary status and merit preliminary to its present internationally dominating position.**
>
> **Standardization should begin early in the growth of an industry. It is trusted sincerely that those engaged in laying the foundation of the aeronautic industry will sense fully the obvious need for standardization in their own immediate field.**

In discussing the history and development of road transport, Major James Paterson says of 19th-century times: "Coaches accelerated their speed to try to compete with the railways, but this knocked the horses out too fast. In 1839, Mr. Sherman, a great road-carrier, admitted that most of his passengers were timid people who funked traveling by rail." Then Major Paterson follows with the significant comment: "Will it be true in a few years' time that the only people who travel by rail will be those who funk going by air?"

This is a suitable text for the various needs of preparation in aeronautics today. It is obvious that the entire world-transportation system must be revamped. Much of the equipment, particularly rail equipment, is obsolete, inadequate or inefficient in view of general developments making for interest, comfort, economy and convenience.

Now is the day essentially for a school of sound thought and consistent conduct in putting our house in order. Standardization is a prime factor in this. The eliminating of immaterial and economically harmful detail differences in construction and the establishing of sound material and dimensional specifications is a slow process and a difficult one, but is vitally necessary. Thus design and product can be improved, cost reduced, time saved, and maintenance facilitated. Interest and other charges due to excessive inventory can be diminished.

Knowledge of the past always illuminates the present and the future. No industry has been more active, or produced more standards, than has the automobile industry. The activity has been maintained for more than a generation, and for over 18 years by the Society of Automotive Engineers and its predecessor. Quantity production is the child, not the father, of sales policy. Merchandized production is the order of the day. This means changes made quickly in step with obsolescence, and restraining undue size of inventory of special parts. The true balance can be maintained only by due consideration of market demand and producing cost.

Standardization of the true type is in no sense stagnation. It must not interfere with, but always be subordinate to, progress in design. It assists greatly in progress in design. It must always meet the exigencies of style change. The phase that should dominate is that which will facilitate the coming and maintaining of the great desiderata, a seller's market and user satisfaction. Style dominates in all today save bare necessities. Non-essentials of distinctive design must be standardized for economy and for the needs of service. In the production of distinctive designs, the savings made possible by the use of standards are essential. For low cost of production the number of aircraft parts cannot be reduced greatly. This means standardization.

Standardization does not impede necessary change. It facilitates the making of needed changes economically. It decreases the original cost and the cost of scrapping special designs which must of necessity be relatively expensive. Without standardized product, the machine-tool is virtually valueless. There is flux condition of constant change in economics. Economy in manufacture is vitally necessary, in view particularly of unsolved problems in cost of marketing and distribution. The time of planning and devising ways and means to reach a destination should precede the taking of the vital part of the journey.

Naturally, the present condition of very satisfactory prosperity in the automobile industry is due in large part to the ideas and action of far-sighted pioneers it was fortunate enough to enlist. This is merely corroborative of Mazur's statement that, notwithstanding the many reasons advanced for recent American prosperity,

[1] M.S.A.E.—Secretary and general manager, Society of Automotive Engineers, Inc., New York City.

"The causes and consequences of the present economic day must be found in those factors which influenced and motivated the actions of American business-men." All great transactions come into being by reason of correct analysis and deduction by steadfast men of clear insight.

Growth and Revision of Standards

The accompanying curves indicate the number of automobile engineering Standards that have been established by the Society during the last 18 years. Fig. 1 shows the growth of the number of Standards cumulatively from year to year. Fig. 2 lists the number of Standards and Recommended Practices promulgated during each calendar year. Fig. 3 shows curves of the number of Standards and Practices revised or cancelled each year. The peaks and valleys of the curves in Figs. 2 and 3 illustrate the influence of the conditions brought about by the World War and the reconstruction period.

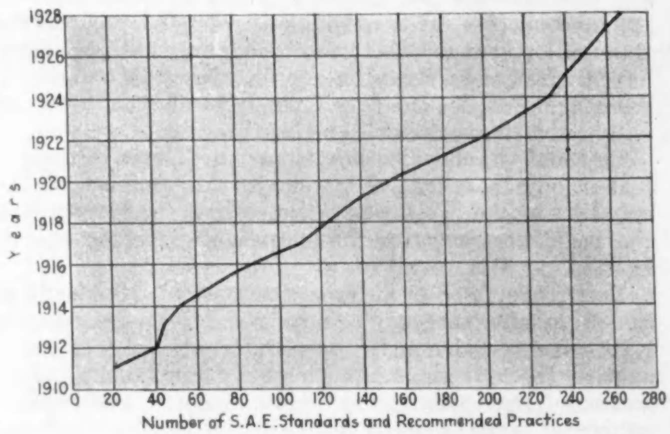


Fig. 1—Cumulative Number of S.A.E. Automobile Engineering Standards and Recommended Practices

This Increase from 20 in 1911 to 268 in 1928 Does Not Include Standards Relating to Other Automotive Fields. Approximately 100 Relate, However, to Aircraft Parts and Materials. Individual Groups of Specifications Are Counted as One Standard

Standardization follows and conforms approximately to changing industrial conditions and progress in design. The specifications covered in the accompanying curves are automobile standards; that is, they apply primarily to passenger-vehicles and motor-trucks. They relate to materials, dimensions, testing, and nomenclature.

In addition to these Standards and Practices, there are S.A.E. Standards that bear on similar matters in other automotive fields such as those of aircraft, tractors, industrial engines, watercraft and motorcycles. Good progress is also now being made in standardization relating to machine-tools and other equipment and materials used in the manufacture of mechanical goods in general. The S.A.E., in cooperation with other organizations, already has adopted standards for certain classes of taps and the blanks for work-checking gages.

A number of automobile Standards were established by the Association of Licensed Automobile Manufacturers before the Society of Automobile Engineers (the former name of the Society of Automotive Engineers, Inc.) became active in standardization work. The S.A.E. became the custodian of the A.L.A.M. Standards in 1910, taking over the right to revise, cancel or supplement these.

Sixty-three different automobile subjects are at present before Divisions of the S.A.E. Standards Committee, these being exclusive of the matters under consideration by the Aeronautic, the Agricultural Power-Equipment, and the Motorboat Divisions of the Standards Committee. Of the said 63 automobile subjects, 15 are new; the others involve revising or adding to existing specifications.

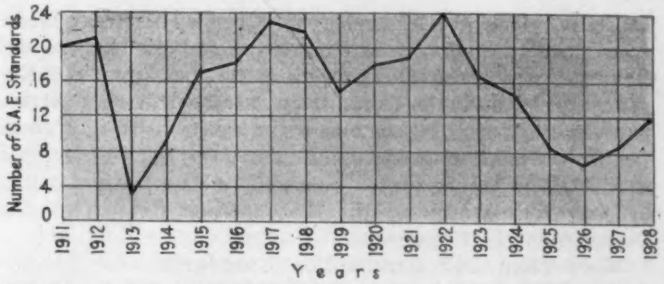


Fig. 2—Yearly Record of S.A.E. Automobile Engineering Standards and Recommended Practices Adopted

This Does Not Include Standards Relating to Other Automotive Fields. The Valleys and Peaks Reflect the Influence of Conditions Caused by the World War and the Recovery Period

Activity in the Aeronautic Field

At the present time a dozen or more subjects are under study by the Aeronautic Division, with additional items coming up frequently. Today, as has been the case for some time, a large percentage of the work of the S.A.E. Standards Committee relates to aeronautics.

In 1916 the American Society of Aeronautic Engineers was merged with the S.A.E. At that time the Airplane Engine Division of the latter was organized. Since the inception of the aeronautic industry, the S.A.E. has held areonautic meetings, at which to date upward of 200 papers have been presented by leading authorities. During the last year, 15 per cent of the text of the S.A.E. Journal has been devoted to aeronautic engineering.

The Society has done much aeronautical engineering standardization work, this having been through the various phases of activity during the World War, the quietude after the war, and the present greatly increased

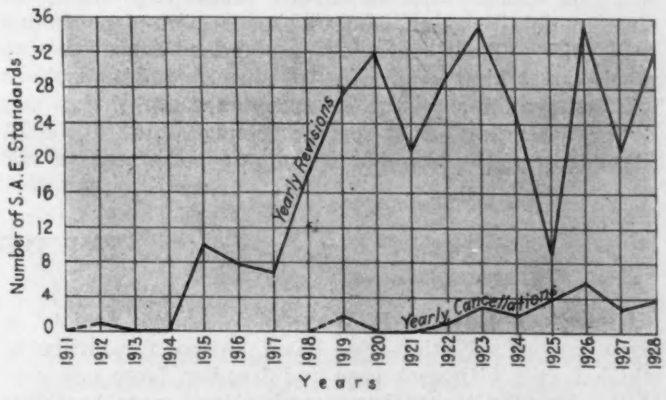


Fig. 3—Record of Revisions and Cancellations of S.A.E. Automobile Engineering Standards and Recommended Practices

Standards Relating to Other Industries Are Not Included. The Relatively Large Number of Yearly Revisions since 1917 Reflect the Continuous Effort To Keep the Standards Abreast of the Progress of Practice in the Industry, While the Small Number of Cancellations since 1921 Indicate the Care Exercised To Avoid Adopting Standards That Will Have Only Brief or No Value

interest. The S.A.E., with the Bureau of Standards, sponsored the committee that developed the Aeronautic Safety-Code, under the procedure of the American Engineering Standards Committee. It took a very active part in the formulation and promulgation of this code, which has been of great value in organizing to meet the needs of civil aviation. It served as the basis for the present regulations of the Aeronautics Branch of the Department of Commerce.

More than 260 Automobile Standards and Recommended Practices are published in the S.A.E. HANDBOOK. Approximately 100 of these relate to aircraft parts and materials. In totaling the number of these standards, individual groups of specifications such as those that cover steel of a given type are counted as one standard. All standards are revised, semi-annually, when necessary, the HANDBOOK being reprinted completely in revised form in March of each year.

VALUE OF S.A.E. ENGINEERING STANDARDS

As to the value of the S.A.E. Engineering Standards to the automobile industry, there can be no doubt. It is generally recognized that they have been and are of the greatest value. The vital lesson of cooperation was learned in the early days of the automobile industry. The standardization idea crystallized into concrete achievement before the American automobile achieved importance in a worldwide sense. In fact, it was largely due to the adoption of this standardizing policy, and joint engineering work on the part of leading producing companies, that the American car achieved the necessary status and merit preliminary to its present internationally dominating position. The late Henry Souther, the first Chairman of the S.A.E. Standards Committee, very wisely advocated that the automobile industry accept standards as rapidly as possible, keeping them uptodate by following the art closely and making necessary changes from time to time. Portions of a construction can properly be standardized at a given time; other details must await further development.

Standardization should begin early in the growth of an industry. Too many standards, or ill-considered standards, are worse than none at all; but certain things must be standardized to obviate undue expenditure of time in detail design, and to prevent untold confusion in service. To be accepted, a standard must have so much merit that engineers, producers and executives will see good reason for its acceptance.

The assigning of a specific money-value to S.A.E. Standards in the automobile industry is of course not easy. An analysis of estimates made by a large group of engineers and executives indicates clearly that, had the standards not been established, the price of present-day automobiles would be at least 15 per cent greater than it is.

INFLUENCE EXTENDING THROUGHOUT WORLD

The automotive industry is extending its sphere of influence throughout the world. It is laboring strenuously to foster and coordinate as much as possible those phases of automotive production that are essential to industry and human welfare. In international trade, it is obvious that the need for maintaining standardization that will make possible the interchangeability of numberless materials, parts and accessories, is inexorable.

The automotive industry and the public may well be grateful to the founders of the Society, and to the many splendid men who have served devotedly and with conspicuous success for a generation. They have furthered the development of motor-vehicle transportation. They have trained the younger men. They have defined economies and adduced modern principles in the fields of automotive manufacture and maintenance.

Rational standardization is an invaluable economic tool in any industry. A predominating number of the members of the Society have understood for many years the basic necessity for automotive engineering standards.

There are four evolutionary stages of standardization; namely, company; industrial (inter-company); National (inter-industry); and international. In aeronautics, the first stage has arrived without much public notice. Great progress is being made in the second, industrial stage, toward the third, or National, stage. This standardization movement will in all probability soon reach the international stage, because aeronautic transport will do more to establish vast international communications than any system now used.

It is trusted sincerely that those now engaged in laying the foundation of the aeronautic industry, which will be on a scale different from, and perhaps greater than, that of any prior industry, will sense fully the obvious need for standardization in their own immediate field. To this end, constant and ever-increasing cooperation of truly loyal nature is necessary. The full support of designer, producer and executive is essential. A good nucleus of personnel for this work has been enlisted. It is desired that it be as thoroughly representative as may be, so that fullest possible progress can be made.

THE DISCUSSION

CHAIRMAN EDWARD P. WARNER[2]:—As the Society is organized on a Nation-wide basis, so too, for airplanes which travel with such ease and freedom from one side of the Country to another, standardization, to be effective, must be at least National in scope; and, on some points, international standardization is desirable in the extreme.

We must make our own beginnings before we can talk about international agreement; and, whether or not we have that ultimately in view, a first and most important step, so far as we consider standardizing of any value at all, is to get together within the American industry, to secure agreement among the builders and operators of aircraft on the forms that their parts should take for the sake of interchangeability. Interchangeability is in the interest of ease of maintenance, of convenience of replacement far from home, of the convenience of the user, and in the interest as well of economy, which can proceed only from mass production of standardized articles.

There has been, I suspect, in some quarters in the aircraft industry a little suspicion of this work of stand-

[2] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, Navy Department, City of Washington.

ardization as undertaken by the Society; a suspicion which has proceeded from two or three possible sources. First, since the aeronautical engineer has frequently, though erroneously, thought of the Society of Automotive Engineers as an organization exclusively concerned with the welfare of the automobile industry, there has, I think, been an occasional feeling in some quarters that standardization conducted by the S.A.E. is a step toward the swallowing up of the aircraft industry by automobile interests. I can speak with warm personal conviction in saying that there is no such intent in the minds of those engaged in the standardization work, and no such probable consequence for the future.

Another reason why standardization has at times perhaps been suspect is that it is feared that it may exercise an undue restraint upon individual initiative; that it may interfere with the engineer's free development of his own idea; feared, too, that it may, in some more or less mysterious way, put the builder at a disadvantage in relation to his competitor who is using the same designs of small individual parts and elements. That is, each individual may be expected to profit by the progress made by the industry as a whole, which I think we must regard as a benefit rather than a drawback.

Again, there has been, I think, a fear that standardization means that research work and independent investigation will have to be carried on in part for the benefit of competing groups.

I mention these feelings that have certainly existed in some cases because it is well, if there be objections or drawbacks to standardization, or any other activity, to bring them out frankly and fully into the open and meet them, if they can be met.

The best answer to the fear of the suppression of initiative, to the fear that one would be working for the benefit of his competitors, and so on, is found in past experience in other industries. Results elsewhere certainly indicate that the aircraft industry can take this work, done solely in the interest of the industry and its customers, warmly to its heart.

Should Begin When Industry Is Young

I may, perhaps, remark upon the rather obviously fallacious nature of the argument that standardization should not be undertaken too soon; that it should wait until the industry has developed further, very far, in fact. Certainly, if there is to be any measure of agreement among manufacturers on dimensions, forms and practices, the time to reach that agreement is before each manufacturer has arrived at a practice of his own and solidified it by installing machinery to fit. The easiest time to get together is when the industry is in the formative stage, although, of course, the work cannot be completely done then; in fact, it never can be completed, for further development of design and further research make it possible always to take up new directions of possible standardizing activity and to make occasional advantageous modifications in existing standards.

Most of us here began driving cars and motorcycles long before they were as common as they are now, and before the work of the S.A.E. was very well advanced. I well remember my first motor-vehicle, which had, I think, not one standard part upon it. About 1909, if I wanted to get a new bolt, I went to the manufacturer of the motorcycle and paid him 25 cents for a bolt which would have been expensive at 3 cents; a nut for the bolt cost 15 cents. Even the threads were not standardized. Everything had apparently been made to order, with the object of making interchangeability impossible and requiring everybody to come to the original builder for spare parts and to pay high prices. That was to the advantage of the builder so long as the machine broke down in the immediate neighborhood of his establishment, but it was provocative of warm remarks on the part of the owner when it broke down far from home and the repairman preferred to put in a stove-bolt which would not fit.

That has all passed, and while we have more automobile agencies now on every highway than we had 18 or 20 years ago, even where there is no agency we often find that we can improvise or use a part or accessory made for another car, with little fitting or none at all. Certainly our progress has been enormously simplified, aside from any benefits that may have resulted to the industry, because the industry has recognized that its own interests lie in following a single common path, so far as that is practicable without undue restraint upon individual endeavor and originality.

The leadership in the work of standardization in the United States has always been taken by non-official bodies, except, to be sure, for the activities encouraged and stimulated within those non-official bodies by Government agencies in certain of the mass-production industries, especially of raw materials, in the last few years. It has been the general rule, in the more complex industries or those dealing with more complex products, such as automobiles, to say nothing of airplanes, that the engineering society has led the way, and certainly no other engineering society here or abroad has been more active in that field than the Society of Automotive Engineers.

Reading and Education

ONCE a man's reading has progressed to the point where one book leads to another and one subject suggests another, his real self-directed education has begun. Begin with those subjects that have a close relation to your present purpose in life, or some hobby of intense interest, and then follow the subjects that branch out from this. Do not scatter! The great difference between being educated and uneducated does not always consist in the *amount* of reading and study accomplished, but in the amount of *intelligent, well-directed* reading and study that is done. The education we get when working for a purpose is most apt to be of value.—F. R. Robinson in *American Magazine.*

Naval Air-Tactics and Aircraft Design

Discussion of Commander E. E. Wilson's Los Angeles Aeronautic Meeting Paper[1]

THREE basic ways in which naval aviation can assist the battle fleet to attain victory are stated, and the aircraft are classified as fighting, observation, torpedo and bombing, and patrol planes. The primary and secondary uses of the types are set forth, and, since their tactical employment controls the features of their design, a brief sketch is given of the tactical considerations of fleet air-work.

The development of naval aircraft to date and the trend of future development are then described. As naval fighting planes must be carried on the ships of the fleet and must have the utmost possible performance and service ceiling compatible with low landing-speed, their size and weight have been reduced by the use of air-cooled radial engines and the intelligent employment of light alloys and ingenious detailed construction. The latest development in this class is a single-seater designed around the Wasp 500-hp. engine and equipped with a supercharger. It is light but is designed to carry a considerable load of bombs.

In the two-seater class the Corsair has been developed around the Wasp engine as a general-purpose machine. As a landplane it was adopted for airplane-carrier use in scouting squadrons. Now it is made readily convertible for use as a seaplane by the installation of a float, and as an amphibian by the attachment of retractible landing-wheels.

Through their use for a multiplicity of purposes, the former torpedo and bombing planes grew too large and a complete right-about-face was necessary. The problem was solved by the development of the Hornet and Cyclone 525-hp. air-cooled engines and the use of light alloys. The present Martin bomber is lighter by more than a ton than its immediate predecessor, has greatly improved performance and has flying qualities approaching those of the lighter craft.

Patrol planes also have gone through an evolution and now have metal hulls and wings and are built around the Cyclone and Hornet engines. They have recently established a large number of seaplane records. It seems desirable now to begin to redesign the airplane structure, with the purpose of making the patrol airplane as small as possible consistent with seaworthiness, long range, habitability for the crew, and offensive characteristics.

At the meeting, the author supplemented his paper by running comment on the lantern slides as they were shown. As printed herewith, this points out notable features of the four types of airplane for service with the fleets and the latest developments in them. All are air-cooled and are highly satisfactory for their various specialized services.

Assistant Secretary of the Navy Edward P. Warner, in the discussion, points out that in rating naval aircraft many considerations must be taken into account and everything else cannot be sacrificed to performance. Loads that must be carried, visibility from and comfort in the cockpit, and ease of maintenance are of great importance. Differences that exist between countries in their political, strategic and geographic situations must be considered in design. Therefore, battle tactics that influence design are not only general but may be highly specialized.

COMMANDER E. E. WILSON:—Last Monday the 15 squadrons comprising the Aircraft Squadrons, Battle Fleet, passed in review over Mines Field and Los Angeles. To many persons this was just so many airplanes, about 132. The purpose of my paper was to point out some of the influences that led to the design of these airplanes and some of their methods of employment.

Referring to the pictures that illustrate the paper, Fig. 1 is the new Boeing fighter delivered on June 30, 1928. This particular one is the Boeing design 89. We notice three or four striking features: first, its compactness, the very short fuselage; then the corrugated metal tail-surfaces, and a long-nose Pratt & Whitney engine. I am now about convinced that the advantages to be gained by a long propeller-shaft are hardly commensurate with the cost of multiplying the types of engine. If we can standardize on engines without losing too much performance we should do so. Notice the first attempt to streamline the air-cooled cylinders. The high seat-position is intended to give adequate vision over the engine and to reduce the blind angle about the wing. The airplanes preceding this used adjustable seats to enable the pilot to have a high, a medium or a low position. In the design shown in Fig. 1 it was hoped to do away with the adjustable feature in the interest of simplicity. The wasp engine, as it is operated here, develops about 596 h.p.

The particular Vought Corsair shown in Fig. 2 is Secretary Warner's airplane and is the 02U1 model. The design has now passed into the 02U2 model, which differs in that the center section of the upper wing has been converted into metal and cut out so as to improve the combat precision. Its performance is very high, approaching closely that of contemporary single-seaters although it carries 500 lb. more load.

STANDARDIZING ON VOUGHT FOR SCOUTING

In the illustration of the Vought adaptation of amphibian gear, Fig. 3, we have cut out the details of the arresting gear. Notice the very simple application of wheels to the float, in which there is a double step. In the later model, we have gone back to the single step. This gear differs from the Loening type, in which the wheels, when retracted, are half concealed in the float. In the landing condition, the wheels are out. The indi-

[1] Published in THE JOURNAL for October, 1928, p. 353. The author is chief-of-staff to Commander of the Aircraft Squadrons, Battle Fleet, San Diego, Cal., and a member of the Society. The abstract of the paper is reprinted for the convenience of readers, and is supplemented by a summary of the discussion herewith printed.

cations were that the cost in weight and resistance involved by semi-housing the wheel was out of proportion to the advantages, so we now are standardizing on the Vought type and are about to go into production on it as the standard carrier scouting-plane. It can be catapulted from the battleship as a spotter; it has a universal landing-gear; and its all-purpose features make it very attractive for a general-utility machine. The wind-driven radio generator shown on the upper wing in the picture is about to be replaced by an engine-driven generator.

The Martin T4M1 bomber shown in Fig. 4 carries the Hornet engine, is of light-weight duralumin construction, and has excellent flying-qualities for so large an airplane. Fifteen of these which were on review on Monday were recently brought out from Cleveland. The little window is in the bombing compartment. One pilot flies in the front seat, which affords vision for deck landing. The second pilot flies in the second seat. The machine-gunner flies in the rear seat, and the radio operator works in the compartment lighted by the two windows. How to make this large craft suitable for deck landings, in which very fine control is needed, was a problem. Although it is heavy when fully equipped with a torpedo, it now is as handy in landing as are lighter airplanes.

As I indicated in the paper, the next development may be the elimination of much fuel and the reduction in size of the airplane. These three airplanes comprise the real fleet aircraft, that is, those placed on the decks of the fleet. Our patrol airplanes are being manufactured by Donald Douglas, and the first are expected to be delivered in January. From this it will be seen that we have four types of fleet aircraft, all air-cooled and all highly satisfactory for the purposes for which they are intended.

Many Factors Affect Design

Edward P. Warner[2]:—The title of Commander Wilson's paper is suggestive of many forms of influence and interaction between aeronautical engineering and the military and naval operations of aircraft. Commander Wilson has set forth some of the interactions, and especially their results in present-day naval aircraft design. Others come to the mind of every designer who has worked on such aircraft. He has shown the care that must be used in making comparative estimates of the qualities of military aircraft. It is obvious that we cannot rate a military aircraft alone on speed in miles per hour without knowing whether it is carrying any load and what it is capable of doing when it rises to 20,000 ft. We cannot compare surface vessels in terms of speed alone. If they are commercial ships of the sea, we must reckon with the problem of whether it is possible to operate them at a cost that shippers and travelers will pay for transport at the speed theoretically available. If they are naval vessels, we must reckon with fighting power of the armament and with the defensive power represented by armor. And so it is with the airplane. We cannot sacrifice everything else to performance. We have not only to carry a military load, but have to reckon with other factors affecting both offensive and defensive power, such as comfort in the cockpit, visibility from the cockpit, and ease of maintenance of the airplane, which are of vital importance, and to improve which it is justifiable to make sacrifices in speed or rate of climb.

[2] M.S.A.E.—Assistant secretary of the Navy, for aeronautics, Navy Department, City of Washington.

Why Air-Cooled Engine Was Adopted

There are other points which we can reckon with in full only when we take account of the exact political, strategic and geographical situation with which the airplane is being designed to cope. It is evident that naval and military airplanes differ. They are likely to vary between Great Britain and the United States, for example, because of the difference in the position of the countries. As one concrete example of the way in which differences arise between the airplanes of one country and those of some of its neighbors, there is a certain country that has at certain times in the past been peculiarly concerned with air defense of important political centers which have been potentially subject to air attack from overseas areas not far removed. It obviously has been of special importance that the airplanes used for defence against such an attack should be ready to go into action in the minimum time; therefore, two things became of predominant importance and justified extended sacrifice in other qualities: first, rate of climb; and, second, the ability to get away in the minimum number of minutes and seconds after an alarm was received. The air-cooled engine was used in some cases even when it entailed a disadvantage compared with its water-cooled companion. We need not seek now to find any counterbalancing factors to excuse any deficiency of performance in the air-cooled engine, because deficiencies no longer exist; but the air-cooled engine was used even in a much earlier day because it could take the airplane into the air within a shorter time after the propeller was first turned over to start it than could the water-cooled engine. In some other countries that might have been unimportant as compared with other problems.

National differences are marked in the case of the flying-boat. In some cases it is of pre-eminent importance that the flying-boat should be able to operate with the fleet and lie in exposed harbors or no harbors at all. In that case, seaworthiness becomes the predominant consideration, and other qualities may have to be largely sacrificed to seaworthiness and the ability to rise into the air from rough water. In another instance, the flying-boat is planned, as a result of a strategical situation, to operate more or less independently of the fleet and maintain surveillance for long periods over large areas of water far from a fueling base. In that case, long range is the predominant consideration.

So, it is not merely in general terms that battle tactics influence design tactics, but the influences which Commander Wilson has set forth may be not only general but highly specialized. It may be necessary, as naval or governmental power changes and as aeronautical engineering develops, to modify our aims in working on specific types of aircraft; and it definitely is the case that the aim we have in working on scouting or patrol and fighting airplanes will be quite different at any time from that of certain other powers. Therefore, those who are not concerned primarily with naval aircraft, and to whom these things are not already axiomatic, should guard carefully against over-rash comparisons and make sure that all the data—not merely in the purely aeronautical classification, but also those which affect the problem which is given the aeronautical man to work with—have been taken into account.

Methods of Obtaining Greater Power from a Given Engine

By T. J. Litle, Jr.[1]

Semi-Annual Meeting Paper — *Illustrated with* Drawing

Demand for increased car-performance forces manufacturers to provide more powerful engines. It is desirable to obtain the increased power without designing a new engine, particularly in the case of large-scale manufacturers. The author lists possible means of doing this as making increases in the speed, the volumetric efficiency, the compression ratio, the thermal efficiency and the mechanical efficiency; and explores each of these methods in the light of latest developments in engine design.

Among the concrete suggestions are greatly increased valve-lift, hydraulic valve-gears, multiple carbureters, injection of vaporized fuel into cold air, cutting out the fan at high speed, and the use of superchargers. Higher compression generally involves changes in cylinder-head design, which are covered in some detail.

Subjects covered in the discussion include lubrication, roller-chain camshaft drives, form of combustion-chamber, availability of engine power, and two-cycle engines. Several speakers express opinions also as to what constitutes a high-speed engine.

Because of the insistent demand for more power from passenger-car engines, every producer is faced with the problem of either designing new powerplants or revamping his present designs to obtain more power. To most of the large-production companies this is a great problem. The powerplant that was sufficient for all requirements last season will have to be increased in capacity, in all probability, on account of the growing demand for better performance. Besides, the bodies have been increased in size and weight in many cases.

I shall attempt to show how the power output of an existing engine can be increased. Of course, it usually is easier to clear the boards in the engineering department and lay down an entirely new design to meet the requirement, but obviously it is more sensible to step up the performance of the current model, and this is usually possible. The modern automotive engineer needs to be alert in observing every improvement in engine design, and it is surprising to find what can be accomplished by taking a leaf out of the other fellow's notebook. I will admit that it is more difficult to increase the power output from a given engine than to design a new engine. If the former can be done it probably will save the company a great deal of money, and the results can be obtained more quickly.

In this paper I shall merely attempt to catalog these possibilities. Some engineers dislike to revamp an old engine, but I hold that an engineer should be given fully as much credit for redesigning and improving an existing engine as would be given for an entirely new design.

Methods of increasing engine power for a given displacement can be classified as increasing (*a*) the speed, (*b*) the volumetric efficiency, (*c*) the compression ratio, (*d*) the thermal efficiency, and (*e*) the mechanical efficiency. As these classes are more or less interrelated, many of the suggestions to be made will possibly affect two or more of the divisions.

In spite of the fact that many engineers are averse to higher engine-speed and are reverting to the clumsier slow-speed engines, containing great masses of cast iron, I thoroughly believe that engine speeds will be further increased. It is true that greater care must be used in manufacture, better materials must be utilized, and much more attention must be given to the balancing of all moving parts; but, to offset this, there is the saving of a great deal of metal. In all probability the valve-springs will need to be redesigned with increased tension for the higher speed, using better materials and possibly adopting multiple springs.

We also should reduce the weight of reciprocating valve-parts if possible, at the same time securing material with higher physical properties. This applies to the push-rods as well as to the valves themselves.

The weight of all reciprocating and rotating parts should be reduced. Connecting-rod weights can be decreased considerably by machining all over, retaining the present I-section, or preferably they can be of the light tubular type, or they may be made from one of the light aluminum-alloys.

There is a possibility of future development in metals lighter than aluminum, such as beryllium, for pistons. The cast-iron piston at present has become practically obsolete.

Piston-pins can be reduced in weight by employing a better grade of material and by taper boring from each end.

Crankshafts can be greatly reduced in weight by machining all over and drilling to remove internal metal that does very little work. Recently ingenious machines have been devised for doing this in simple operations. Often much superfluous metal is used in crankshafts, because of carelessness in design. The weight of the flywheel can be reduced when the engine speed is increased.

Certain types of front-end-drive chain are considerably smaller and lighter than those used more commonly. These are a distinct advantage at high speed, and in some cases they are less expensive than the heavier chains. The sprockets can be made correspond-

[1] M.S.A.E.—Chief engineer, Marmon Motor Car Co., Indianapolis. Mr. Litle wishes to acknowledge assistance in the preparation of his paper from H. E. McCrady, R. C. Chesnutt, C. A. Chayne and R. P. Lewis, engineers with the Marmon Motor Car Co. Mr. Lewis now is with the Salisbury Axle Co., Jamestown, N. Y.

ingly lighter, and they are now being produced from die-castings.

Stamped-steel pulleys for generator, fan and water-pump drives are being used to reduce both weight and cost.

New Vibration-Damper Hinted

The heavy flywheel-type of vibration damper will in all probability be obsoleted very shortly by an entirely new type of device. Not only will this save considerable weight, but it is a multiple-purpose device, reducing almost all the torsional-vibration periods in the crankshaft, which was not accomplished by the former heavier devices. Incidentally, the cost will be greatly reduced.

Inasmuch as a unit powerplant includes the transmission and clutch, much attention should be paid to these units. Recently light-weight clutches have been designed that have greater capacity than those used a year ago.

All reciprocating and rotating parts should be more carefully balanced. It is obvious that the engine may be more successfully operated at high speed if the parts are very carefully balanced, in addition to being made lighter; and, as we have learned to do these operations very quickly, the expense is really no serious item.

It is highly desirable to balance the piston and connecting-rod assembly selectively. It costs no more to weigh the assembly than to weigh the parts separately and assemble afterward, and the assembly weighing is much more effective.

If all manufacturers would pay more attention to balancing there would be much less antagonism to the high-speed engine, as a large part of the offensive vibration is due to lack of balance in the reciprocating and rotating parts. All automotive engineers can remember distinctly the arguments against the high-speed engine of ten years ago, when we knew little or nothing about balance. That engine has become the slow-speed engine of today.

Increasing the Volumetric Efficiency

Increasing the area of valve opening by increasing the diameter and lift of the valves is one way of obtaining greater volumetric efficiency. It has been supposed generally that the maximum effective valve-lift is about one-fourth of the port diameter, which gives a valve-opening area approximately the same as the port area; but this has been disproved recently. Twice that lift would be better if it were mechanically possible. Now inventors have presented schemes such as the hydraulic valve-gear to accomplish this end.

It often is impossible to increase the size of the valves for an increase in volumetric efficiency, so that the higher lift will be welcomed by many designers, especially for existing engines. The differential-piston principle used on the hydraulic valve-lift will give a greater mean-opening area, which incidentally increases power. Another decided advantage is the more quiet operation. It is not difficult to adapt this to an existing engine.

When the speed of an engine is increased, better results usually are obtained by increasing the duration of the inlet-valve opening.

For overhead-valve engines, new cylinder-heads are frequently designed. If this is done there are many possibilities for increasing the power, one of which is the use of dual valves.

Great increases in power have been obtained by redesigning inlet manifolds. There seems to be no limit to this development. This applies to the entire inlet-system from the carbureter to the cylinders. In existing engines core changes have been made to utilize venturi passages very effectively.

It is extremely important to avoid abrupt reversals of airflow. This principle is well recognized by ventilating engineers, who have large volumes of air to distribute through conduits. Easy sweeps and turns impede the flow much less than abrupt or square elbows. In fact, an abrupt reversal of flow represents an impedance five times that of a long sweeping turn.

Possibilities of Carbureter Improvement

The use of dual or multiple carbureters has greatly increased the power on several different engines. It will be remembered that, before the use of the supercharger, this was extensively resorted to on racing cars, and it is being used at present in Europe.

Cold carburetion now is being studied carefully for its direct effect on the volumetric efficiency of an engine, and I think it is fair to prophesy considerable power-increases when this is perfected. I further believe that shortly we may see fuel injection, in conjunction with cold air, successfully adapted to our present-day engines. Finally, the separate vaporization of the fuel to be commingled with cold air promises to be a distinct aid in obtaining more power.

All of the developments listed unquestionably will result in more power, and I believe that car-producing companies are paying too little attention to these possibilities. The work is being left to comparatively small accessory-companies and consulting engineers who, having neither the financial backing nor the proper facilities, often find it difficult to cooperate with the car companies.

Better design of the exhaust system, to reduce back-pressure, is highly desirable. Exhaust manifolds can be air-cooled to contract the volume of the hot gas quickly. The area of the exhaust-valve opening can be made larger by increasing the diameter or the lift, as described previously for the inlet valve.

The exhaust back-pressure can be decreased by by-passing the exhaust through the center of the muffler. While not considered as directly increasing the power of an engine, it does so in effect.

Increasing the Compression Ratio

Now that non-detonating fuels are available, the compression in most engines can be increased. This results in a greater expansion-ratio, which really is responsible for the higher thermal efficiency. This probably is the most economical way of increasing power, as it can be done with very few changes. It has been the practice to supply high-compression engines optionally; but I believe that now, with the many improved oil-cracking processes, all fuel will be improved to the point where higher compression can be used generally.

When the compression is increased, many combustion-chambers will need to be redesigned, as it has been found that the maximum permissible compression-ratio, to avoid detonation, seems to be a factor of the combustion-chamber design. Many combustion-chambers have zones of low turbulence which need to be removed.

Greater thermal efficiency will be obtained through the use of metals in the cylinder-head having conduc-

tivity higher than that of cast iron. Special synthetic cast-iron alloys now are available for this purpose.

Relocation of the spark-plugs with increased compression usually is found advantageous, resulting in an increase in power and a decrease in detonation. Coupled with this, probably, will be the use of a better designed, or cooled, plug. Multiple spark-plugs result in a power increase in many cases, particularly in large cylinders.

Increasing the Thermal Efficiency

As present-day powerplants are notoriously inefficient and wasteful, they offer to the research men wonderful possibilities for improvement, principally for cutting down the power losses through the exhaust and cooling systems. Thermal efficiency can be bettered, of course, by increasing the compression ratio and volumetric efficiency, as previously described.

An automatic method for controlling the inlet temperature would be an advantage. We need little if any heat in the upper range of engine performance. Thermal efficiency could be still further increased by insulating the piston-head.

It would be desirable to have means for thermostatic control of the water temperature that would maintain a more nearly constant operating-temperature.

In most engines there are local hot-spots in the cooling system. These should be removed. On nearly every engine that has come under my observation, I have found the water circulation restricted around either the exhaust valves, the inlet valves, or the spark-plugs.

Increasing the Mechanical Efficiency

Lighter weight of reciprocating and rotating parts has been discussed previously. Better materials, of higher physical properties, are being presented to us continually. The use of extremely hard surfaces will be a distinct advantage. Material such as nitralloy, developed by the Krupp interests in Germany, are extremely interesting. It has long been known that gas hardening is desirable, but only recently has it been discovered that the addition of approximately 2 per cent of aluminum to alloy steel effects remarkable catalytic action in enabling the alloy to absorb nitrogen to an astonishingly high degree at a comparatively low temperature in an atmosphere of ammonia, and such a skin-hardened nitride surface will scratch glass readily and is very much harder than any carburized surface. The hardness is beyond anything that we dared dream of a couple of years ago, and this will allow us to use very much higher engine-speeds, at the same time giving much greater bearing-life.

To reduce friction losses, lubrication conditions may be improved by carefully filtering the oil. Many engines have been reduced in power because the bearings were scored and roughened by particles of foreign material in the oil. In many cases this has occurred before the owner received the car. Positive and direct pressure-lubrication to all moving parts is highly essential in high-speed engines. The cooling of oil to preserve proper viscosity is another important item.

Stiff Bearings Are Wasteful

Engine bearings should be so fitted that they can be moved or rotated freely by hand. The running-in of stiff engines is extremely bad practice and usually results in the scoring and wearing of bearings. All closely fitted surfaces should be true and in full contact.

It is surprising to note the increase in power on a given engine after its aluminum pistons have been given the proper prolonged heat-treatment. I have noted considerable power-losses in many engines, after operating for a short period, that have been due to the growth and distortion of aluminum pistons.

Antifriction bearings have been used successfully on aircraft engines and racing cars for such parts as crankshafts and connecting-rods. While these cannot be used on the cheaper cars, they might easily be used on cars of the better grades.

The effective power of an engine can be increased by cutting down the friction losses in the accessory units, such as the fan and generator, by the use of ball-bearings. The engineer also should check very carefully the power absorption in all the accessory units. Keeping the accessory units as small as possible leaves more power available for the propulsion of the car. An improperly designed fan will absorb an unbelievable amount of power, particularly at high speed. It would be desirable to disconnect the fan automatically at high speed, as it is then of very little use.

Final Notes

A comparison of engine performance usually is based upon the number of cubic inches of displacement per horsepower. This is correct only in comparing engine performance in respect to fuel consumption. When comparing engine performance in respect to car performance, I think that a more accurate comparison would be the engine weight per horsepower, as it is a distinct advantage to keep the engine weight as low as possible by careful design and the extensive use of the lighter alloys. In this connection, it seems strange that the price of aluminum has not been reduced to supply this demand. Even at its present high price, there are certain small parts of the engine for which aluminum can be used successfully in place of cast iron at little additional cost.

It may be that superchargers will be made as accessories, to be adapted to existing engines. If this is done, a given engine design may be perpetuated over several years to meet the demand for more power, for this is the most effective method known for increasing engine performance.

THE DISCUSSION

Chairman B. B. Bachman[2]:—While I realize that this paper deals primarily with the powerplant, the practical value of the paper is the effect on car performance, and that involves the question of the gear reduction between the engine and the wheels.

I have always felt that, in my own field, which is entirely foreign to that which is being discussed, the question of engine speed is misinterpreted; and that whether an engine is a high-speed or a low-speed engine depends more on the gear ratio in the rear axle than on the design of the engine itself. It is probably like the famous question as to which came first, the hen or the egg. I do not suppose that we can agree on the relative importance of these two factors.

Joseph A. Anglada[3]:—We should be grateful to Mr.

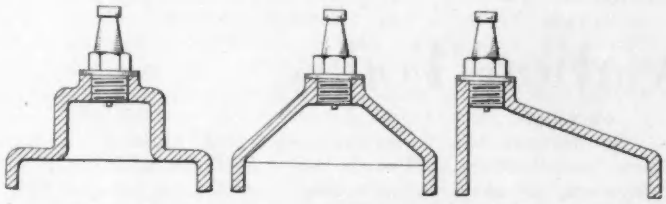
[2] M.S.A.E.—Engineer, Autocar Co., Ardmore, Pa.

[3] M.S.A.E.—President, Anglada Motor Corp., New York City.

Lítle for crystallizing and reducing to writing the thoughts which most of us have had relative to engines. I cannot agree with Mr. Bachman that changing the gear ratio makes a high-speed engine, which is entirely different from a low-speed engine. Prejudice seems to exist against high-speed engines because it is thought that they wear out too quickly. Abroad they do not wear out any faster than our American slow-speed engines, but they cost more.

Mr. Lítle mentioned the use of roller chains. It is surprising that they are not more commonly used. I am running roller chains now over three sprockets, up to speeds of 2000 ft. per min., and the chain operates entirely satisfactorily at that high speed. The cost and weight are less, the chain is stronger, and I believe it has longer life than the silent type of chain.

Not very much was said in the paper about lubrication. In a single-cylinder experimental engine, running



EXPERIMENTAL COMBUSTION-CHAMBER SHAPES

Fig. 1—Constricted Cylinder Fig. 2—Right Cone Fig. 3—Oblique Cone

wide-open continuously at about 2000 r.p.m., it was found that the performance was spotty with an oil pressure of about 25 lb. per sq. in. However, when the oil pressure was increased to 60 lb. per sq. in. without other change, the variation in maximum horsepower did not occur. I believe that more attention might well be paid to the lessons on engine lubrication to be learned from the aviation field.

Relative to the increase in volumetric efficiency, it was interesting to learn in connection with work on a sleeve-valve engine that, by increasing the compression from 5-1 to 6-1, an increase of about 10 per cent in horsepower was obtained with ordinary fuels and no detonation; also a temperature decrease from 180 to 140 deg. fahr., as shown by the radiator thermometer, on the same roads and with approximately the same air-temperature. The increase in mileage per gallon of gasoline was from 20 to 22 miles.

EXPERIMENTS WITH COMBUSTION-CHAMBERS

The shape of the combustion-chamber, as Mr. Lítle pointed out, is important. As an experiment, we constructed a cylindrical combustion-chamber with the spark-plug placed centrally at the top, as in Fig. 1. From that, we got a certain horsepower. Changing the shape of the combustion-chamber to something like that of Fig. 2, keeping the compression the same, we got an 8-per cent increase in power. Changing it again, to the shape of Fig. 3, we got a 5-per cent increase over the cylindrical type. This shows that it is possible to affect the performance of an engine very definitely by making very simple changes.

A. L. BEALL[4]:—Mr. Lítle rather flatters the oil industry when he says that, with the improved cracking processes, all fuels will be improved to the point where higher compression can be used generally.

A year ago the oil industry as a whole was considered a little backward in that it was not providing high-compression fuels generally, or as rapidly as it should, in the opinion of some. Last year's work has resulted in a general improvement, but not of all fuels. Mr. Lítle's statement shows that the progress has been satisfactory, and his prophecy should come true within the next few years.

ACTUAL POWER OUGHT TO BE AVAILABLE

HERBERT CHASE[5]:—I sometimes wonder whether it is possible, under road conditions, to realize the maximum power of the engines that we have. It is probable that most engines do not yield their maximum power during normal driving at the instants when we need it. We "step on the gas," but the engine does not always develop the power that it is capable of yielding, until it has run some time. It "picks up" slowly. We sometimes condemn such an engine, although it is capable of giving high maximum power, simply because it is not capable to giving that power quickly. Some condition necessary for rapid acceleration is lacking. The gear ratio is an important factor, but I think that the problems of carburetion and manifold design ought to be given much more study. If they could be solved, the engine itself probably would be found to yield adequate power in most cases.

Certain engines have critical speeds at which the carburetion is not satisfactory. Once above these speeds, these engines give good power; but in service the driver is unable to profit by this power because some manifold condition such as "loading," it may be, prevents. The engine, being unable to pass the critical speed, is condemned as lacking power. So it seems that more study should be given to obtaining the power of which the engine is capable, under the conditions that are met on the road.

Drivers usually say that a car is very powerful if it accelerates rapidly. Oftentimes the engine has not reached anything like its maximum power during the period of acceleration, but if it picks up quickly he is satisfied with the performance and calls the engine "very powerful." That apparently is one condition we should strive to attain. I am convinced that it often could be obtained by minor improvements in the intake system without resorting to a larger engine or to extensive alterations in the engine itself.

W. R. STRICKLAND[6]:—A great deal of work, of course, has been done along the lines of Mr. Chase's suggestion. Anyone familiar with the operation of an engine will know the different results that can be obtained according to whether a hill is taken en route or after stopping. Those conditions are observed especially at Uniontown Hill, which is a famous test-hill. People from the Middle States traveling through that region have no trouble until they reach Uniontown Hill, where the conditions under which they attempt to climb are very different from anything they have previously seen. At the proving ground we find quite a difference according to whether we run around the track before climbing the hill or climb it time after time without other running. Much work is being done on carburetion, heating and the like, to correct that condition.

[4] A.S.A.E.—Engineer, refined-oil department, Vacuum Oil Co., New York City.

[5] M.S.A.E.—Engineer, Erickson Co., Inc., New York City.

[6] M.S.A.E.—Assistant chief engineer, Cadillac Motor Car Co., Detroit.

In conclusion, I should like to make the statement that a high-speed engine is one that will run at high speed smoothly and quietly. If it will not do that, it is not a high-speed engine.

TWO-CYCLE-ENGINE DEVELOPMENT

LEE W. OLDFIELD[7]:—At a recent meeting of the Indiana Section the discussion of superchargers brought up consideration of the two-stroke cycle, and Mr. Duesenberg mentioned an engine that he had seen at Valparaiso University. I have seen this engine on three occasions running slower than 85 r.p.m., with no load. I have never heard it miss. I do not know how fast it will run, but it seems to me that the two-stroke cycle offers more possibilities than anything else for doing all of the things we desire, with light weight.

[7] M.S.A.E.—Consulting engineer, Chicago.

T. J. LITLE, JR.:—My paper was dealing only with existing engines, not building a new one, and I agree with Mr. Oldfield that the development of which he speaks is extremely important and probably actually is coming.

Remarkably high speed has been obtained from certain racing engines. Although a racing engine is not a passenger-car engine, I think that we can get inspiration from racing engines. Those little high-speed engines are built and balanced so carefully that they operate very smoothly at high speed. Nothing is thought of 7000 r.p.m. in racing cars in this Country and 11,000 r.p.m. in Italy, so a 2500-r.p.m. engine cannot be called a high-speed engine; it is a low-speed engine, in my estimation. Within a few years there will be some really high-speed engines built in this Country.

Commercial Aviation Today

THE problem of commercial air-transport is not technical development but traffic development. The present widespread interest in flying promises to solve this problem. It seems probable that within a few years airplanes will carry a large part of the first-class mail, and considerable express and mail other than first-class, for distances greater than 500 miles. For distances up to 1200 miles, many of the communications now sent by telegraphic night-letter will go by air. It probably will not be many years before passenger transport by airplane will be as important as either express or mail transport.

When the Armistice was signed the combined airplanes of Great Britain, France and Germany numbered about 60,000. The United States had produced nearly 14,000, purchased 6000 from the Allies, and trained about 10,000 pilots.

Appropriations for the work of the aeronautical branch of the Department of Commerce aggregated $550,000 in the fiscal year 1927; $3,791,500 in 1928, and $4,361,850 has been voted for the current fiscal year. More than 7000 miles of airways have been lighted to date and it is planned to light 4000 miles more by June 30, 1929. In addition to establishing airways and licensing aircraft and airmen, the Department of Commerce has collected and disseminated much useful information concerning traffic statistics, maps and other aids to navigation, and on the construction and management of airports.

OPERATIONS OF COMMERCIAL AIRPLANES

There are now more than 40 airlines operating on a fixed schedule over airways of 13,000 miles. Twenty-three of these carry mail. Contracts have been awarded for seven additional mail routes on which operations will soon commence. More than 20,000 lb. of mail and express are being carried daily. The Department of Commerce lists 123 manufacturers of aircraft exclusive of companies producing only engines or accessories.

The Government had licensed, identified or granted temporary numbers to 6528 airplanes and licensed 3196 pilots up to Sept. 1, 1928. Letters of authority to operate had been issued to 2334 additional pilots. Permits issued or pending to student pilots numbered 5906.

The cost of the Government-operated air-mail in the fiscal year 1927 was 97 cents per mile flown with mail, of which only 8.6 cents per mile was expended for gasoline and oil. However, this total cost does not include several items of expense such as depreciation, insurance, business solicitation and taxes which a private company must bear. On the other hand, some economies are possible with private management.

The average mail revenue received by the air-mail contract operators in 1927 was $2.32 per lb. This was equivalent to 66.8 cents per mile for the distance actually flown with mail. The air-mail postage rate of 5 cents for an ounce or less became effective Aug. 1, 1928. This does not mean, however, that the Government must now pay a difference of about $1.50 per lb. Letters are much under an ounce in weight, averaging about 40 to a pound. The rate for mail weighing over an ounce is 10 cents for each additional ounce. Some mail, however, is carried over three or four routes with one payment of postage.

PASSENGER AIR-RATES

The average passenger air-rate in the United States in 1927 was 10.6 cents per mile. In Europe it was 8 cents per mile. However, the average passenger rate per mile in the United States for companies doing no mail business is about 14 cents per mile. With the present traffic it is very doubtful if a company carrying passengers only can make adequate allowance for depreciation and show a profit at such low rates. These rates cannot be compared directly with railroad fares because the mileage by air is usually considerably less than by rail. Passenger-carrying by mail companies at rates between 10 and 15 cents per mile is profitable because the volume of mail is as yet much less than could be handled with the same organization, and in many cases with the same number of airplanes.

Standardized production of airplanes and parts will reduce both the initial and maintenance costs of equipment, but all reductions made possible by technical improvements in the next few years will be insignificant compared with the reductions resulting from increased traffic.—F. L. Simmons, of National Bank of Commerce, in *Commerce Monthly*.

Effect of Six-Wheel Vehicles on Highway Design

By T. H. MacDonald[1]

Transportation Meeting Paper

TWO distinct phases of the subject are the physical and the economic, both of which are included in the conclusions stated in the paper, based on investigations made by the Bureau of Public Roads.

It is as pertinent to inquire what effect the highways have on the motor-vehicle as to inquire what effect the motor-vehicle has on the highways. Mutual adjustment must be made if real economy is to result.

Two general conclusions that may be drawn from the observations presented are that the six-wheel vehicle offers a desirable and effective answer to (*a*) the problem of the load in excess of the normal desirable limit of weight for the four-wheel truck, and (*b*) the problem of the load equal to the heavier four-wheel truck in areas where road conditions do not permit the maximum wheel-load concentration.

Deductions regarding deflection, deformation and tension in concrete pavement by single and multiple wheel-loads are listed, and references are given to reports on truck-wheel impacts conducted by the Bureau with the cooperation of the Society. Data from the impact tests indicate that, for two trucks carrying the same load and identical except for the rear-end construction, the unsprung component of the impact reaction of the six-wheel vehicle is about one-half that of the four-wheel vehicle.

Necessity for the construction of the greatest possible mileage of paved highways in this Country has resulted in American engineers building roads that are carrying the greatest tonnage on the lightest-built roads that is being attempted anywhere in the world; and the motor-vehicle industry would not have it otherwise. Proof exists that economical transportation is secured, except in limited areas, by a net-load limit of 5 tons; and the wheel-load concentration called for by a vehicle having this capacity is within the safe limit for rural pavements of modern standard types. A large percentage of the mileage is not safe for greater loads, and lower-class roads, constituting 90 per cent of the total mileage in the Country, are incapable of carrying trucks with 8000-lb. wheel-load concentration at certain seasons.

Solution of the problem is not load limitation below the economic requirements of transportation, but limitation of wheel-load concentration by permitting the use of six-wheel trucks fitted with pneumatic tires.

APPROACH to a discussion of this subject involves two distinct phases: the physical, which has to do with the engineering facts, and the economic, which embraces the facts of transportation. We have the attitude of mind of the public to contend with, from the viewpoints of both the highway engineer and the motor-vehicle designer and manufacturer. After a long series of investigations and detailed research-projects extending widely into each of these fields, sufficient information has been developed, analyzed, and made available for use, to enable us with much confidence to support definite conclusions as to the utilization of the motor-vehicle and its effect upon improved highways.

The question has frequently been asked: "What is the effect of the motor-vehicle upon highways?" This may, with equal pertinency, be countered with: "What is the effect of highways upon the motor-vehicle?" A mutual relationship exists from which each must profit or each must suffer. A mutual adjustment must be made if real economy is to result. Such an adjustment as surely precludes uneconomic restrictions upon the size, weight and speed of the motor-vehicle as it excludes undue size, weight or speed upon the road.

The general conclusions which may fairly be drawn from the presentations here included are that:

(1) The six-wheel vehicle offers a desirable and effective answer to the problem of the load above the normal desirable limit for the four-wheel truck.

(2) The six-wheel truck offers a desirable and effective answer to the problem of the load equal to the heavier four-wheel truck in areas where road conditions do not permit maximum wheel-load concentration.

In these conclusions are combined both the physical and the economic phases of highway transport in a manner to promote real economy. They embody the principle of mutual adjustment of the motor-vehicle and the road. To support these conclusions, the physical data are first submitted. Many factors determine road design. Considered as a load-supporting structure, the truck wheel having the heaviest concentrated load becomes the determining factor in fixing the necessary strength of the roadway. It is evident that only those types of construction for which the stresses may be computed or measured lend themselves to structural design. The design of other types must be based more or less on experience, but the consideration of the so-called flexible types of pavement would not lead to very different conclusions. The data presented are confined to the influence on road design from the single angle of the concentrated wheel-load on types of roadway on which the stresses are determinative; that is, the so-called rigid types. Since it may be assumed that the interest of the automotive engineer does not extend to competitive types of road construction or materials, this discussion may be further limited to the relative effects on the design of the road as a structure from the application of the maximum load through a single wheel or single axle and through multiple wheels or axles.

Influence of Vehicles on Rigid Pavements

Passing for the moment the matter of the magnitude of permissible truck-wheel-load concentration, the following conclusions were reached by the Bureau of Pub-

[1] Chief, Bureau of Public Roads, Department of Agriculture, City of Washington.

lic Roads in 1925, after a series of tests in which the elastic behavior of a rigid pavement was studied when subjected to the influence of four-wheel and six-wheel vehicles[2]:

(1) The deflection of a concrete pavement is directly proportional to the loal applied (within the limits of this investigation).

(2) A load passing along the test pavement (uniform thickness 6 in.) 9 in. from the edge of the pavement produced approximately twice the fiber deformation in the edge of the pavement that was caused by the same load passing along a path 21 in. from the edge.

(3) The tension produced in the top of the pavement due to counterflexure between the wheels of a six-wheel vehicle is less than the tension produced in the bottom of the pavement directly under the wheel, regardless of the axle spacing.

(4) In the case of six-wheel vehicles, the maximum tension produced in the pavement seems to be a function of the wheel load and not of the axle spacing, at least between the limits of 3 and 10 ft.

(5) Within the deformation limits obtained in this investigation (maximum unit fiber-deformation of about 0.0001 in. per in.), the fiber deformation in the pavement is directly proportional to the load.

(6) In a pavement slab of uniform thickness the maximum deformation occurs along the edge of the slab for both four-wheel and six-wheel vehicles.

During the following year Dr. H. M. Westergaard made a theoretical analysis, by purely mathematical methods, of the stresses produced in concrete pavements by wheel loads. In this study the case of the six-wheel vehicle was investigated.[3] For the conditions assumed, the following important conclusion was drawn:

> One may draw the conclusion that the main part of the state of stresses at a given point is due to a wheel load right over the point. In the case examined, the contribution due to the three additional rear wheels of the six-wheel truck is of less importance than that due to the one additional rear wheel of the four-wheel truck.

Subsequently, the Illinois State Highway Department conducted a series of tests along lines similar to those pursued by the Bureau of Public Roads, and its findings are entirely in harmony with the conclusions quoted above.[4]

Impacts of Four and Six-Wheel Vehicles

All of the foregoing researches concerned static loads or rolling loads with very little impact.

The Bureau of Public Roads, in the course of its investigations of motor-truck impact, a research in which this Society has cooperated actively, has obtained some data on the relative impact reactions of four-wheel and of six-wheel vehicles.[5] These data indicate that, for two trucks carrying the same load and identical except as to the rear-end construction, the unsprung component of the impact reaction of the six-wheel vehicle is about one-half that of the four-wheel vehicle, all conditions of test being the same.

Desirability of the Pneumatic Tire

In general, the heaviest loads are carried on solid tires, but all the investigations prove the advantage to the road of the pneumatic tire. Were it possible to build perfectly smooth roads and to maintain them so, there would be no substantial difference in road-deteriorating influence between the solid and the pneumatic tire when carrying equal loads; but such a condition is not possible to maintain.

It is not necessary here to go into an elaborate discussion of construction practices, effect of frost and moisture on the subgrade, fatigue of materials of construction, thermal changes with attendant distortion of the road slabs, and many other influences. The fact that the road builder contends with a variety of adverse conditions, many beyond his control, is certain to produce road surfaces that are not perfect planes and cannot be maintained as such. Such surfaces suffer more from the impact of truck wheels carrying solid tires than from penumatic tires. The impact of a solid tire exerts a pressure on a pavement which may be equal to two or three times the static load, under the same conditions that would result in the pressure exerted by a pneumatic tire being only a small additional percentage above that of the static load. It will be recognized that we do not hold that dynamic pressures or impacts can be translated directly into equivalent static-load facts; I make this statement only for the purpose of comparison. This comparison does not imply an unusually rough road surface; rather, it is a condition which might be called a normal operating condition. Therefore the conclusion is apparent that, to carry the same load, the multiplication of wheels, if this changes the wheel-load concentration so that pneumatic tires are economical, is a very great advantage to the road.

Application of Facts to Economic Transport

Up to this point only the physical relations and effects have been considered herein. Unfortunately, engineering discussions have all too frequently stopped at this point, to the detriment of engineering leadership. The proper goal of both the automotive and the highway engineer is exactly the same; that is, the most economical highway transportation. Each in his own field must work back from this objective, not independently, but with intelligence and sympathy. Thus, while the physical facts are important, their economic application is the real objective.

With limited exception, the roadways of this Country are relatively new. The construction of our modern highways through the application of engineering principles and under engineering supervision had its inception with the establishment of the first State highway departments about 1890 in a few of the Eastern States. From the beginning the same necessity has been a large factor in the design of highways. The engineer has constantly been faced with the problem of producing the maximum mileage of serviceable roads; so the design of roads has been as light as is possible consistent with the traffic. Road surfaces were placed on new sub-

[2] See *Public Roads*, October, 1925, p. 165.
[3] See *Public Roads*, April, 1926, p. 25.
[4] See *American Highways*, October, 1927, p. 29.
[5] See *Public Roads*, June, 1926, p. 79.

grades. This does not mean that the surfacing always followed at once the grading, but, even where the first settlement had taken place, the roadbeds were far from final consolidation.

As State road-building started and acquired some momentum in the East about a quarter century ago, the old roadbeds have become well consolidated; but these first roads were designed for the traffic of the day, the horse-drawn vehicle, with sections, alignment and locations adapted to that type of traffic. The new traffic, differing so much in speed and wheel-load concentrations, demanded relocations, realignments and heavier construction. To some extent the earlier construction was such that it has been possible, by increasing the width and thickness of road metal, to use these old roads as part of the modern system. This is true to a limited extent in the New England States and in the Middle Atlantic States east of the Allegheny Mountains, where we find conditions that correspond somewhat to those in England and on the European Continent; adequate roadways built through continuous betterment and maintenance over a long period. But it is necessary only to observe casually to become aware of the large extent to which new roadbeds are being required as an integral part of these oldest highways. Sections where the alignment is being straightened, corners rounded by easy curves, by-pass roads constructed around areas of city congestion, and existing roadways widened require new roadbeds.

In the rest of the Country, by far the larger part, practically no rural highways adequate for present traffic existed prior to about 1914. From this brief review it is evident that highways for modern traffic are new.

Typical American Road Problems

By far the major portion of our paved rural highways has been built since 1920. The insistent demand has been for greater mileage. The highway engineer has had no option to secure the maximum mileage; he has had to design roads as light as he believed would reasonably serve the traffic. This is the typical highway problem of the United States, as it is with all other of the newer countries. In a sense, this Country departed from all established standards and historical precedents. We have estimated that the old Roman roads, if built under modern conditions, would cost about $300,000 per mile, perhaps more. No nation could afford them in quantity. The highway engineers and officials of the United States are building roads that are carrying the greatest tonnage on the lightest roads that is being attempted anywhere in the world, and the time has not yet come when this policy may be changed. Nor is it to the advantage of the motor-vehicle industry to have it otherwise, for every new mile adds to the potential service of the motor-vehicle.

The cooperative highway-transport surveys made by the Bureau of Public Roads and various State highway departments, covering many typical States, have accentuated the utility of freight-carrying motor-vehicles but have conclusively shown that, except for certain areas such as terminal areas in industrial districts and the arterial highways connecting them, the 5-ton truck is the maximum size selected for general use, the number of trucks above this size being very small. There is, apparently, abundant proof that economical transportation is secured, outside of the relatively limited areas named, by a net-load limit of not more than 5 tons. The wheel-load concentrations called for by such a unit are within the safe load limit for rural pavements of the modern standard types. But a very large percentage of the mileage is not safe for greater loads and there is no evidence at this time to justify their heavier construction.

Reasonable Wheel-Load Limits

It seems from the foregoing that the road and the freight-carrying vehicle might be brought together by adopting weight limitations for rural roads as follows:

For general use on improved roads, 8000 lb. per wheel

For terminal areas and arterial roads connecting these, 9000 lb. per wheel

For municipalities, limits as prescribed by ordinance

These maximum wheel-loads may be applied to either the four or the six-wheel truck.

If bridges are designed under the standard specifications of the American Association of State Highway Officials, they will carry without serious overload the six-wheel truck with these wheel loads.

The maximum truck-wheel load is not the only factor influencing road design. Speed, tire equipment, tire width, and sprung and unsprung weight have an important bearing. But these are common to all trucks, and the subject of this discussion is the relative influence of the six-wheel and the four-wheel truck. It should be emphasized, however, that the wheel loads here proposed must be strictly held to apply only to the manufacturers' rated capacity. Any regulation should embody stringent prohibition of overloading and require a minimum of unsprung weight in the design of the truck.

Construction will be designed which will come up in all respects to what the designers believe the customers should have, and such conscientious construction naturally must come into competition with those products which are not so conscientiously designed. It seems to me that something in the field of regulation may be applied to a condition that may exist in the commercial field to the embarrassment of the better class of manufacturers. We have the same difficulty to deal with in the matter of letting contracts to the low bidder. How to award the contracts to the best bidder has been a matter of great puzzlement to us for a long time, particularly under a ruling that if a contractor can furnish a bond he is a responsible bidder. We do not agree with that conclusion, but are bound by it; so we have adopted the policy of requiring pre-qualification of bidders. We endeavor to make certain before we accept a bid from a contractor that, if he is a low bidder, he will be also an acceptable bidder. In the same way, it seems to me that, if it can be fairly and carefully worked out in proper truck legislation, a sort of pre-qualification which at least establishes fair conditions of competition can be enforced upon the manufacturer. That is a desirable criterion in the commercial field.

Tire equipment also must be carefully specified and required to be maintained in perfect condition. These factors are all of such importance in a regulation to provide for the proper use of the pavements that they must be assumed to be fully and intelligently stipulated

as a condition precedent to any discussion of scientific road design.

Low-Cost Roads

All that has been said so far applies to those areas in which, on the State highway systems, standard pavements are being built. In those States, however, there is a large mileage of roads which cannot be improved with paved surfaces within any reasonable time. Moreover, in a very large section of the Country, particularly in that section lying west of the Missouri River and extending to the Pacific Coast States, little hope can be entertained for many years of any considerable mileage of paved roadways on the main highways that will be capable of carrying trucks with 8000-lb. wheel-load concentration. We are devoting the Federal-aid funds to the improvement of a system consisting of 7 per cent of the public-road mileage in each State. The State highway-systems are somewhat larger, comprising at this time, however, less than 10 per cent of the public-road mileage.

The only hope for adequate surfaces, not only upon a large part of the secondary mileage constituting 90 per cent of the whole mileage, but also of a considerable per centage of the mileage included within the State highway-systems, is to build up and strengthen relatively light low-cost surfacings through continuous betterment and maintenance methods.

I have tried to bring out throughout this paper the thought that we are in the transition stage in this matter; that the conditions which we know prevail today as to the load-carrying capacity of our highways will change on our main thoroughfares in five years, and in ten years will have become materially improved. These load limits of which I have spoken will be safely carried by a large percentage of the mileage of roads designed and built today. Heavier loads will be carried safely, but there will be weak spots which, at certain times of the year, would be broken down. Under the intensive maintenance that is in general effect throughout the State highway-systems and is extending to the local roads, these weak spots are continually being worked out of the roads.

I suppose that today, on the main roads of France, the question of load limits is of perhaps no moment, because those roads have, so far as carrying capacity of the road structure is concerned, proved their ability. The greatest concern in France is with preserving a top surface on the national roads.

During the dry seasons, the untreated-gravel or crushed-stone surfaces of roads in this Country are capable of carrying heavy loads, but on such untreated surfaces dust has become more than a nuisance; it is a serious menace to the safety of the road and an evidence of the rapid loss of the surfacing material. There is an insistent demand for the application of bituminous treatment to these surfaces. They will carry a large amount of traffic with moderate maintenance, but cannot safely withstand wheel concentrations of the intensities suggested for the standard pavements. In these areas speed also is an important factor; in fact, speed seems to be growing in importance in its relation to truck transportation.

I do not mean that a large percentage of the whole mileage of such roads would not carry safely these concentrations, or even heavier concentrations, but the weak spots would break down and the moment the surface is broken deterioration becomes very rapid and the maintenance per mile amounts to a large figure. The whole truck industry, including the men who desire to sell trucks and the men who desire to use trucks, is faced with a not very clearly defined attitude of mind on the part of the public against a heavy load, as such. It is the business of the highway official, the automotive engineer, the motor-vehicle manufacturer and the motor-vehicle user to place before the public these facts as to load and wheel concentration. It is a rather involved subject that will require time and considerable effort to place properly before the public, through such discussions as the Society is having.

Limitation of Wheel Load the Solution

The solution of the problem is not load limitation below the economic requirements of transportation, but rather the limitation of wheel-load concentration by permitting the introduction of six-wheel trucks fitted with pneumatic tires. There is every reason to believe that this is the proper solution, rather than the drastic limitation, through legislation, of the gross loads which may be carried on any type of truck.

In conclusion, it seems apparent from the foregoing discussion that sufficient evidence exists to point the way toward truly economic transportation; that is, economic loads without the imposition of unsafe loads upon highway surfaces, through the use of the six-wheel trucks; also to prove that their use may extend with different wheel loads to the most concentrated industrial centers and to the most sparsely settled areas. There is nothing to indicate that the conclusions first stated are unsound from the standpoint of reasonable use of our improved highways.

This whole discussion is built on the consideration of the rural highway, and not upon the application of wheel loads to city streets, which presents a very different problem. The critical stresses are induced in the very edge of rural pavements, and it has been found by careful observation that the heavy truck follows closely the edge of the paved strip on rural roads. The differential that existed between the fiber stress in the pavement when the truck wheel was 9 in. from the edge and when it was 21 in. from the edge will be recalled. There again we feel the reaction of the public mind toward the user of the heavy truck. He has been called, in impolite language, a "road hog" so long that he has become bashful enough to stay over on the very edge of the road. That is satisfactory to the man who wishes to pass him, but it imposes the worst possible condition on the road itself. A number of critical conditions prevail on the relatively narrow strip of roadway with which our rural highways are now improved which do not prevail on city streets, and the problem of the wheel load for city streets becomes quite different

A considerable part of the data on which this paper is based has been brought together or has been developed through a cooperative investigation carried on in which this Society took part with the Bureau of Public Roads, and we are very appreciative of that cooperation. We think that in that type of cooperation lies a way toward a really economic use of the highways. By "economic" I mean from the point of view of the road user, who expects to make a profit on his haulage business, and also from that of the manufacturer, who expects to make his living by selling trucks to the users.

THE DISCUSSION

J. X. GALVIN[6]:—Right now we have a problem in Chicago. I am on a committee representing four interests of public haulers and we are dealing with a situation that seems to be created by the fact that a committee of the aldermen are taking their theme from information they are gathering regarding alleged practices in different States of the Country relative to truck-weight regulation. I have kept fairly well posted on the situation. We have been told unofficially and on no reliable authority that the automotive engineers and this and that engineering body are recommending this and that, and that the Bureau of Public Roads has said if you do thus and so it will ruin the streets.

We are going into the matter thoroughly with the object of establishing, once and for all, what is an economic and efficient basis for truck-weight regulation, with the idea that we shall preserve our streets and give the taxpayer and the public hauler some basis on which to work, so that, at least over a certain period, we can buy equipment and know that we shall not be regulated off of the streets through the whim or fancy of some alderman who happens to have a piece of pavement in his district that may be ruined through the practice of overloading by irresponsible truckers.

I hope, if it is in order for me to suggest it, that the Society will not make any recommendations or advance any rules for the use of any special truck equipment, because our aldermen may look at your recommendations with magnifying glasses. We are going to make a fight for efficiency and try to do it intelligently, and we hope possibly to be able to call on some of you to support us with engineering data.

In this connection I noted that, in his paper, Mr. MacDonald called attention to the fact that his recommendations or suggestions were confined to conditions on rural roads and highways, not on city streets.

M. C. HORINE[7]:—One question which came to mind when Mr. MacDonald was discussing the effect of pneumatic tires in respect to road impact and also the effect of six wheels, was this: Of two trucks of the same weight and identical construction except the drive, one equipped with six wheels and solid tires, and the other with four wheels and pneumatic tires, operating at the same speed, which would be likely to produce the greater road impact?

T. H. MACDONALD:—The question of road impact is not so simple as that. It is necessary to know, for example, the amount of spring deflection on both vehicles and a large number of different conditions before the question could have any answer. The probabilities are that, under the conditions suggested, there would not be very much difference in the impact on the road.

[6] President and general manager, Pennoyer Merchants Transfer Co., Chicago.

[7] M.S.A.E.—Manager, sales promotion department, International Motor Co., New York City.

Snow Removal from Highways

IN 36 States where snowfall is heavy, 111,645 miles of main highways was cleared during the winter of 1927-1928, according to reports received by the Bureau of Public Roads. Ever since the practice of removing snow from highways began in 1921-1922, there has been a steady improvement in machines and equipment available, with an increased amount of equipment every year. In the six years, the number of truck plows used has grown from 184 to 3412; and of tractor plows from 281 to 1275. Inasmuch as both types together have multiplied more than elevenfold, and road mileage cleared increased only about fourfold, greater thoroughness of snow removal is indicated. The use during the last season of less than half the number of graders employed in the previous year shows that the grader has been found less effective than the truck and tractor plows.

In 17 of the States, all snow-removal work was done under the supervision of the State highway departments; and in 15 States by both States and counties or other local governments. In only 4 States was the work done solely under local control.—United States Department of Agriculture.

The Practicality of the Airplane

IT is impossible, as yet, to say just what will be the most effective and economical means of bringing air transportation of goods and people to the business organizations of the Country. It may be airport-lines or air taxi-lines, or both of these plus individual planes for certain organizations that can make effective use of them.

Again, our thinking of future possibilities should not be based solely on what we are able to do today. With better landing-fields, lighted airways, emergency fields, more complete weather information, and perhaps new devices to guide the flier through foggy and stormy weather, we shall have multiplied the effectiveness of the airplane many times. These things are not impossibilities. The automobile was of little use until hard roads were built, until garages and service stations became numerous over the Country, and expert mechanical aid was at hand for any emergency. We accept these things in connection with the automobile without thought. We can and we will provide the same sort of thing to increase the usefulness of the airplane.—R. L. Putnam in *Magazine of Business.*

Legislation and the Six-Wheel Truck

Discussion of Ethelbert Favary's Transportation Meeting Paper[1]

DISCUSSION of the paper deals with both the construction and performance of the six-wheel vehicle and with effects of four and of six-wheel trucks upon the highways. The favorable attitude of the Governor and the highway engineers of Illinois toward bills in the House and Senate of the Legislature to permit greater gross weight on six than on four wheels, as a result of an investigation made by engineers of the State Highway Department, is shown by quotations from letters. Questions are raised and answered regarding the claims for reduced unsprung weight and superior traction of the six-wheel vehicle and regarding effective lubrication of the worm drive in the dual rear axle.

Greater loading and unloading time necessitated by a 10-ton vehicle in city and suburban work, as compared with a tractor and semi-trailer unit, is cited as an economic factor.

Statements that any pavement will last indefinitely are deprecated, but experience is said to have shown that loads of 10 and 20 tons can be carried satisfactorily on 8-in. concrete foundations under both flexible and rigid pavement. Reports of the Highway Bridge Committee of the American Road Builders Association and of the American Society of Civil Engineers hold that bridges on primary highways should be designed to carry trucks having gross loads of 20 tons.

ROBERT T. HENDRICKSON[2]:—The Illinois waterway, which is to connect Lake Michigan with the Mississippi River, probably is the most important development for freight transportation in recent years. It will benefit the entire Ohio and Mississippi River Valleys, as well as the Great Lakes region. If the territory is to reap full benefit from the low-cost transportation that this will make possible, it must depend upon something besides the railroads to transport freight to the canal, river and lake ports. This freight must be picked up at the farms and factories in the territory adjacent to the waterways and carried quickly and at a reasonable cost to the various loading depots.

There is no question that the most important factor, and the one on which the success of the waterway depends, will be the motor-truck, for without facilities to handle this business quickly and easily the full value of the waterway will be lost. This project will mean the building of roads from outlying towns and cities to points on the waterway where the freight can be loaded on barges. With the increase of traffic which this project will create, together with the store-door delivery system, we shall be forced either to build wider roads to take care of this increase or to adopt some other type of motor-vehicle which will carry greater loads without damage to the roads.

RESULTS OF RESEARCH IN ILLINOIS

I should like to read a few extracts bearing on the situation as regards the six-wheel truck in Illinois, in which State, next to California, probably more six-wheel trucks are in use than in any other State in the Union.

The Hon. Len Small, Governor of Illinois, in his recent message to the legislature, said in part:

> All of our State highways have been designed and constructed to carry indefinitely the maximum axle load (16,000 lb.) permitted under our laws without deterioration. . . . The roads to be built in the future will be designed and constructed to carry the axle loads permissible under our State laws. . . . Engineering research conducted by our Division of Highways shows that our roads will last indefinitely if we do not abuse them by overloading them.
>
> The research further shows that the governing factor is not the gross load but rather the intensity of axle load and the axle spacing. Consequently, it is quite possible that our laws governing the gross weight of motor-vehicles might well be amended to permit engineering ingenuity to develop motor-vehicles capable of carrying greater gross loads by the use of multiple axles properly spaced. This will serve only to modernize our laws and to permit more modern and more scientifically designed motor-vehicles to be developed.

BUREAU OF PUBLIC ROADS STATEMENT

The United States Bureau of Public Roads, in conjunction with the various State highway commissions, has gone into the matter of road building and maintenance very thoroughly, not only in connection with the uniformity of laws governing the use of roads, but also into its technical aspects.

The Journal of Highway Research, issued by the Bureau, states in part:

> The six-wheel truck is the motor-vehicle designers' solution of the problem presented by demand for vehicles which will carry heavy pay-loads without violation of the restrictive regulations adopted for the protection of the highways. . . . For a given load, the six-wheel truck will cause only about one-half the tensile deformation produced by a four-wheel truck. . . . The motor-vehicle designers have sought to increase the legal carrying capacity of the single vehicle by using four wheels instead of two in the rear, where the bulk of the load is carried, thus doubling the

[1] Published in S.A.E. JOURNAL, December, 1928, p. 605. The author is a consulting engineer, the sales promotion manager for the Moreland Motor Truck Co., of Los Angeles, and is a member of the Society. His paper was presented at the Transportation Meeting by Robert T. Hendrickson as Mr. Favary was unable to attend. A summary of the trend of the discussion is printed herewith.

[2] M.S.A.E.—Treasurer and sales manager, Hendrickson Motor Truck Co., Chicago.

number of axles, wheels and inches of tire width by which the load is transmitted to the pavement. Such vehicles comply with the regulations and can legally carry heavier loads than the four-wheel vehicles.

Illinois Highway Engineers' Findings

Before the bill was passed, which Governor Small had in mind when making the comments quoted, Frank T. Sheets, chief highway engineer of Illinois, wrote to the Committee on Motor-Vehicles and Traffic Regulations of the State of Illinois in part as follows:

> When H. B. 504 was considered in your Committee, I made the statement to the Committee members that our department had been running tests for several months to determine the loads which might safely be carried by the six-wheel type of motor-truck, and that our preliminary reports from these tests indicated that a gross load greater than 24,000 lb. might safely be carried by such a truck without increasing the pavement stresses above the figures caused by the present legal load imposed by a four-wheel truck having a maximum axle-load of 16,000 lb. I made this same statement before the Senate Committee on Roads regarding S. B. 346. . . .
>
> Since that time our tests have been carried to a conclusion and, as a result, our department offered certain amendments to S. B. 346 which were adopted by the Senate. . . . From these tests we have a large mass of engineering data and measurements with which to support the conclusions which have been reached, and, after checking carefully all of the stress measurements and other engineering data we have secured, I concur in the conclusions reported by the engineers in the Division of Highways.
>
> The facts ascertained, after several months of engineering study and actual measurements of pavement stresses in the field, point inevitably to the conclusion that these six-or-more-wheel vehicles which conform to the provision of S. B. 346 may carry safely a gross load of 40,000 lb. provided the individual axles on such vehicles are spaced not less than 40 in. center to center and do not carry an axle load greater than 16,000 lb. The gross load of 40,000 lb. is all that can be carried safely as a concentrated load on our bridges, and for this reason we have insisted that this limit govern all motor-vehicles.
>
> The passage of this measure would, of course, legalize a new type of motor-vehicle which seems to offer a needed solution to the heavy-hauling problem. It is pleasing that truck manufacturers have seen fit to develop vehicles along these lines rather than to insist upon an increase in our 16,000-lb. axle load, which, in my opinion, would be fraught with serious consequences.

The engineers' conclusions referred to by Mr. Sheets are stated as follows in a joint report made to him by V. L. Glover, engineer of materials; H. W. Russell and O. Larsen, assistant engineers of materials:

> (1) The present Illinois standard 9-6-9-in. pavement, which is designed to carry one rear-axle load of 16,000 lb., will carry an additional 16,000 lb. rear-axle load without any greater detrimental effect than that caused by a single axle-load of 16,000 lb., provided the spacing of the axles is kept greater than 36 in.
>
> (2) Under a system of unequal rear-axle loads, the maximum stresses produced in the pavement are not greater than the maximum stress produced by a single rear-axle load of the same magnitude as the greatest axle load in the system of unequal loads, provided the spacing of the axles is kept greater than 36 in.
>
> (3) The stresses produced in the pavement by loads moving at ordinary speeds, disregarding any effect due to impact and sudden application of the load when passing across transverse joints and cracks, are about 90 per cent of those caused by the same load applied statically.
>
> (4) The maximum stresses caused by a truck having the rear axles spaced not less than 36 in. are no greater than the maximum stress produced by the single rear-axle load of a four-wheel truck, provided the individual rear-axle loads on the six-wheel truck do not exceed the rear-axle load on the four-wheel truck.
>
> (5) The effect of impact caused by a six-wheel truck due to irregularities in the pavement surface is not as great as that caused by a four-wheel truck, provided that individual rear-axle loads on the six-wheel truck do not exceed the rear-axle load on the four-wheel truck.
>
> (6) The total gross load on a vehicle may be increased if an additional axle is provided if the spacing between the two rear axles is kept greater than 36 in., and if the load on any individual axle does not exceed 16,000 lb.
>
> In view of these conclusions, we see no reason why Senate Bill No. 346 . . . should not be adopted if, when further amended, it will provide that the maximum gross weight permitted on the road surface through any axle of any vehicle shall not exceed 16,000 lb. nor 800 lb. per in. of width of tire upon any one wheel; that the gross weight, including weight of vehicle and maximum load of any self-propelled (six or more wheeled) vehicle shall not exceed 40,000 lb.; that the axle spacing shall not be less than 40 in. from center to center; and that the axle arrangement shall be such that the proportion of the gross load carried on any axle shall remain constant.

Is Unsprung Vehicle-Weight Reduced?

President W. G. Wall[3]:—Six-wheel vehicles certainly have a great many advantages, though a few disadvantages. I can readily see most of the advantages Mr. Favary has listed, but the claim that the unsprung weight is reduced is a little beyond me. There is reduced unsprung weight on the roadbed for the amount of tonnage hauled, but is the unsprung weight of the vehicle itself less on a six-wheel vehicle? The advantage of the six-wheel vehicle depends greatly upon the method of springing the four driving wheels.

Some of the early six-wheel vehicles rode very little better than the four-wheel vehicles and they were handicapped by the fact that the four rear wheels were not sprung in the proper way or were not connected in a suitable manner. Most of those difficulties have been overcome in the present six-wheelers.

Mr. Hendrickson:—I can show roughly on the blackboard what our particular six-wheel construction does that some of the other six-wheel trucks have not been able to do. At *a* and *b* in Fig. 1 are two worm-drive axles, with the conventional hook-up between them. Beam *c*, together with torque-rod *d*, gives virtually the same effect as one gets with a parallel rule. The great trouble with six-wheel trucks heretofore has been the taking care of the starting torque; they built up too large an angle in the short universal-joint shafts between the axles. We avoid that in two ways: first, the load is carried about 6 in. below the axles so the load

[3] M.S.A.E.—Consulting engineer, Indianapolis.

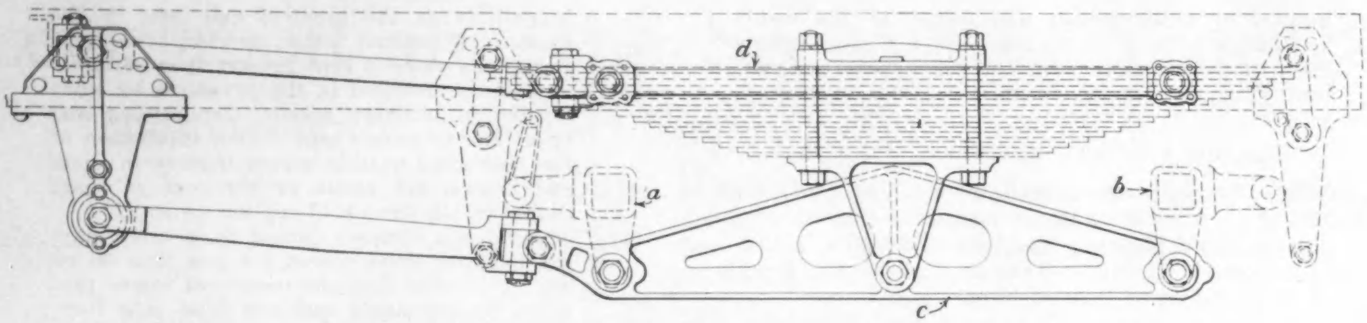


FIG. 1—BALANCED REAR-WHEEL ARRANGEMENT OF SIX-WHEEL TRUCK

Building Up of Too Large an Angle in the Short Universal-Jointed Shafts by the Starting Torque Is Avoided by Carrying the Load 6 In. Below the Axles and by Providing a Torque-Rod, *d*, That Extends Across the Top of the Two Rear Axles. The Axles Are Kept in Line by the Torque-Rod and the Two Carrying-Beams, *c*, One on Either Side of the Pair of Axles

that is carried helps to take care of the torque; second, the torque-rod *d* that extends over the top of the axles takes the balance of the torque. Keeping the axles in line has been another difficulty that was experienced in six-wheel trucks. The designers put a spring between the axles and when the center of gravity of the load would shift, as in going around a corner or when hitting a bump, the axles would have a sort of accordion effect. This resulted in more wear on the rear side of the worm in checking that slap than on the front side of it from driving. We use the one torque-rod at the top and the two carrying beams, one on each side, so we really have a three-point suspension. Every connection is made with steel balls so it can move in any direction without binding.

RELATION OF LOAD AND VEHICLE WEIGHT

CHAIRMAN A. F. MASURY[4]:—How many differentials are used?

MR. HENDRICKSON:—We have one differential in each axle. We have in Chicago probably 60 to 75 trucks that are covering 100 to 150 miles per day and carrying between 11 and 12 tons of sand, gravel and stone, and we are not having any differential or worm trouble of any kind with the construction used. We are getting exceptionally high mileage on tires although the trucks are carrying greater loads than our 5-ton trucks, and we are also getting better gasoline economy than with our four-wheel trucks carrying the same pay-loads.

As regards the unsprung weight, the individual axle in a four-wheel truck would weigh at least 50 per cent more than the individual axle in the six-wheel truck. The damage done to the road is done by the individual blow, not by a multiple blow; it is the concentrated unsprung weight that does the damage.

The most important point and the one that results in the economy of the six-wheel truck is this: A conventional truck built to carry 10,000 lb. weighs about 10,000 lb., but a six-wheel truck weighing not more than 14,000 lb. can carry 20,000 lb. The ratio of the weight of the truck to the load it is carrying is less in the six-wheel than it is in the four-wheel truck. That is the reason for the fuel economy in the six-wheel truck.

A. W. SCARRATT[5]:—Have you had any experience with other than the worm-drive type of axle in six-wheel construction?

MR. HENDRICKSON:—No, that is the only type we have ever used. One thing that surprised us more than anything else is this: We were using in our 3-ton four-wheel trucks an axle that had a rated carrying capacity of about 11,000 lb. The engine in that truck had a 4¼-in. bore, and we have broken several worms and differentials in those trucks when using them for excavating, road work, and so forth. In the first two experimental six-wheel trucks that we built, we used a 5 x 6¼-in. engine, a seven-speed transmission, and two of the same size axles in the rear construction, carrying an axle load of 19,000 lb. per axle. Those trucks have been running continuously for 2½ to 3 years and, with that big engine, we have never broken any worms or differentials in those small axles. That shows that a differential is not needed between the two axles, because we have more power there than one of those individual axles would be able to stand.

LOADING TIME AN ECONOMIC FACTOR

NATHAN CHERNIACK[6]:—My interest in this six-wheel-truck subject is from the viewpoint of the user; I am interested in the economics of operation rather than the mechanical construction. When a load of 10 tons or more is approached, the loading time is considerable, and during the loading time the truck is tied up.

Mr. Favary has compared the 10-ton six-wheel truck with the 5-ton four-wheel truck. Has Mr. Hendrickson compared the six-wheel truck with another unit, the tractor and semi-trailer, to find out whether they are real competitors in certain fields, and specifically has he had any occasion to attempt to sell the user a six-wheel truck in competition with a tractor and semi-trailer representative?

I noticed that in the pictures shown the six-wheel truck was used in hauling bulk materials, such as sand, gravel, bricks, and stone. Is it adaptable to hauling freight in and about the city or for interurban haulage, as for distances like that between Paterson and New York?

MR. HENDRICKSON:—In every place we have been and in all legislative work with which I have had anything to do, the trailer companies have given us the most trouble. The six-wheel truck is simply a refinement of the tractor and trailer, with all the advantages and none of the disadvantages. There is a real field for the tractor and trailer; where the haul is short and the time re-

[4] M.S.A.E.—Vice-president and chief engineer, International Motor Co., New York City.

[5] M.S.A.E.—Chief engineer in charge of motor-trucks, International Harvester Co., Chicago.

[6] M.S.A.E.—Statistical analyst, Port of New York Authority, New York City.

quired for loading and unloading is considerable, they no doubt have and always will have a field. We do not claim that the six-wheel truck is a cure-all. It is designed primarily for heavy loads and to conserve the highways; and secondarily for higher speeds with safety.

It is possible with six-wheel trucks to get in and out of any place that one can with the four-wheel truck, because the wheelbase is no longer; the mean wheelbase is the distance that really governs the turning radius.

Basis of Conclusions Ultra-Conservative

ARTHUR H. BLANCHARD[7]:—Mr. Favary has adopted an ultra-conservative basis in comparing the results of the utilization of trucks of 2½, 5 and 10-ton pay-load capacity. He has based his estimates on conclusions reached by some engineers, and it is believed that no one in the highway engineering profession would question the statement that the basis assumed is entirely fair.

The highway engineers of this Country, particularly under the leadership of the Bureau of Public Roads, are making remarkable progress in research work, but conclusions should not be drawn hastily. It is regrettable that any prominent public officials should broadcast the statement that a concrete pavement, provided the loads do not exceed a certain limit, will last indefinitely, because no pavement will do so. The nearest approach to such an ideal is a stone-block pavement on a reinforced-concrete foundation. This is not said to depreciate in any way the value of the cement-concrete pavement. I am an adherent of its use under proper conditions and with the proper expectation of its life, which many conservative engineers who use all types of pavement estimate, based on experience all over the United States, is between 10 and 20 years.

There is great danger also in saying exactly what the increase in the cost of the pavement must be because of increased loads. Conclusions drawn from the Bates Road tests in Illinois and other experiments are to the effect that the thickness of a plain concrete pavement should be increased from 9 in. for 10 tons to 12½ in. for 20 tons. Based on the experience of the city engineers of the United States and Europe, the loads mentioned have been carried satisfactorily on 8-in. concrete foundations under both flexible and rigid pavements. It is evident that the results of research must be correlated with experience.

Mr. Favary has listed ten economical advantages of six-wheel trucks. I subscribe to all which have a bearing upon the highway. He refers also to the excellent work of L. W. Teller, of the Bureau of Public Roads. I wish to add one quotation from Mr. Teller's article[8]:

> Tests conducted recently by the Bureau of Public Roads indicate definitely that the tensile strength set up in a concrete pavement by a six-wheel truck is only about half as great as the stress produced by a four-wheel truck of the same gross load.

Mr. Favary mentions the argument, sometimes advanced against the use of six-wheel trucks having gross loads of from 15 to 20 tons, that the old and more or less obsolete bridges were not built to carry such heavy loads. His points are well taken in regard to the solution of this problem. Such loads would generally be carried only on roads of primary systems, which, according to the 1920 Report of the Highway Bridge Committee of the American Road Builders' Association and the 1924 Report of the Committee of the American Society of Civil Engineers on Highway Bridge Specifications, should have bridges designed to carry trucks having gross loads of 20 tons.

Load Distribution and Traction

A. J. SCAIFE[9]:—I should like to ask three questions: first, what about load distribution? second, what about traction? third, what about lubrication?

First, I noticed that the load distribution on the six-wheel truck is less than 20 per cent on the front wheels; in fact, in some cases as low as 12 per cent of the gross weight is carried on the front axle. Some time ago Connecticut and Massachusetts had a law prohibiting the operation of a vehicle having less than 20 per cent of the gross weight on the front axle. I do not know whether it is in effect now. The reason for that was that in going down grade, when the roads were wet or icy, it was impossible to control the vehicle on a sharp curve if less than 20 per cent of the gross weight was on the front axle.

With reference to the traction, each of the four rear wheels of a six-wheel vehicle carries 25 per cent of the weight of the rear end, whereas, on a single-drive axle, 50 per cent is carried on each wheel. How is increased traction obtained with less weight? In Cleveland the six-wheel motorcoaches became stuck in the snow while four-wheel motorcoaches went through easily. We have photographs showing this.

Second, I understand that in California, where six-wheel vehicles are being operated from Los Angeles to Bakersfield, over the Coast Range, the worm drive becomes extremely hot, and every means of lubricating to keep them cool has been tried. The latest method has been to circulate the crank-case oil of the engine through the rear-axle worm. Is that effective?

MR. HENDRICKSON:—This is the way we load our trucks: In Illinois we are allowed a gross weight of 40,000 lb. Instead of loading 32,000 lb. on the rear four-wheels and 8000 lb. on the front wheels, we come closer to 28,500 and 9500 lb. respectively. In certain parts of most States the local authorities are so strict that if the load is 100 or 200 lb. overweight they are likely to give the driver an arrest slip. So, not being limited on the front axle, we throw a little additional weight on it to be able to carry the maximum loads permissible on the six-wheel trucks.

Regarding traction, I went out recently to a gravel pit not far from Chicago where the grade coming up from the pit was fairly steep and, with water running out from the gravel, that hill was very slippery. Regardless of how much power a four-wheel truck has, it could not have climbed that grade at all, but the additional traction we get from the four drive-wheels enabled the six-wheel trucks to go up that hill.

Last winter, in the snows, our six-wheel trucks hauling milk came through where the four-wheel trucks did not. The power has a great deal to do with the tractive ability. Regardless of whether a truck has four or six wheels, it must be engineered from one end to the other. A six-wheel truck can have a larger powerplant than a

[7] M.S.A.E.—Consulting highway engineer and highway-transport consultant, Chicago.

[8] See *Public Roads*, October, 1925.

[9] M.S.A.E.—Chief field service engineer, White Motor Co., Cleveland.

four-wheel truck, and it is hardly fair to compare the traction of an under-powered six-wheel truck with a well-powered four-wheel truck, in such cases as snow and snowdrifts, where the snow is being piled up on the wheels.

It should be borne in mind that motorcoaches are geared for higher speeds than are trucks and possibly are not geared for snow.

Traction Surface Spread in Six-Wheeler

Mr. Scaife:—The question I have in mind is about traction, not wheel power. The six-wheel coach stood still and the wheels slipped. The four-wheel coach went through because 50 per cent of the rear-end weight was on each end of the rear axle, whereas with the six-wheel coach only 25 per cent was on each of the four rear wheels. It is the same way with the gravel-pit example. The reason the six-wheel truck went up the grade was because the traction was distributed over a greater area. With dual tires on one wheel, the traction surface is at one spot, but if a truck has tandem wheels the traction surfaces are 45 in. apart. The distribution or the spread of the traction surface is a decided advantage. But in snow the traction surface is exactly the same, and the advantage is greater with the single than the double axle, because of the weight on the vehicle.

Chairman Masury:—I think perhaps the best answer to the question is that we are considering six-wheel trucks a possibility as well as four-wheel trucks.

Mr. Scaife:—The only thought I had was that we should be careful about making claims that we cannot prove. It is not necessary to make such claims. I think the six-wheel vehicle has decided advantages.

Mr. Hendrickson:—I know that in hauling milk from Indiana into Chicago on four-wheel trucks last winter, when we had heavy snowstorms, one dual tire on each wheel was taken off and the trucks got through when they could not get through with dual tires. But for traction in mud or clay, or ability to get in and out of a place, we have demonstrated time and again that the six-wheel truck will go where the four-wheel truck cannot. On a 5-ton four-wheel truck the largest tires that can be put on are two 14-in. tires; that is 28-in. tire width on the road surface. We put four 12-in. tires on our six-wheel truck for carrying the same loads, and get 48 in. That aids in getting in and out of bad places, such as mud, soft dirt, clay, or anything of that kind.

Mr. Scarratt:—Mr. Scaife's question regarding the lubrication of the axles on long-haul work was not answered. I also have heard that operators have had serious trouble with boiling of the oil.

Worm-Drive Lubrication Question

Mr. Hendrickson:—We do not have nearly the heating in a six-wheel worm-drive axle that we do in the four-wheel worm-drive axle. We made extensive tests along that line in hauling cement from Buffington, Ind., to Chicago, a distance of about 25 miles, with the trucks carrying 10 tons and drawing an additional trailer load of 10 tons, and found that the temperature of the worm was far less in the six-wheel truck than it was in the four-wheel truck. This is attributed entirely to the fact that the pressure between the worm and gear is lower, as it is divided between the two axles.

Question:—What kind of lubricant do you use in the axles?

Mr. Hendrickson:—The regular lubricant recommended by the worm-drive-axle men, which is a mineral oil. Most of the trouble, I think, results from improper lubrication; that is, using an animal oil or a mixture of some kind. I think there is no place in a motor-truck where lubrication is so abused as it is in the worm-drive axle.

Mr. Scaife:—We are having trouble keeping the dual axles cool going to Bakersfield over the mountain. It may be that the axles are too small.

Chairman Masury:—The axles must get very hot if they circulate the engine oil. Have you ever done that?

Mr. Hendrickson:—We never have had any occasion to do so. It should be borne in mind that, were the same work to be done with a single axle and with a dual axle, the temperature would be far less in the dual axle. Operators often try to do the impossible with a truck. Some of the first trucks we turned out, which had two 1½-ton axles, were run between Chicago and Detroit. The operators were loading them with 8 and 9-ton loads and drawing an 8 or 9-ton trailer, and the drivers were trying to keep up with the big motorcoaches running between Chicago and Detroit. Our experience with the six-wheel truck has been that we had far less lubrication trouble than with the four-wheel truck.

Mr. Scaife:—I think the matter possibly resolves itself to this: It is not a question of the torque on the axle but one one axle opposing the other on the highway. That, I believe, has been one of the difficulties from the start. When the Goodyear Tire & Rubber Co. started its six-wheel trucks years ago, that continual fighting of the one axle against the other because of the unevenness of the highway generated heat that destroyed the universal-joints, and it was impossible to maintain universal-joints between the two axles until a different method of hooking them up with the torque-rods was adopted. I understand that the Timken Axle Co. has been working on that difficulty for years, and I hoped there would be a Timken representative here who could tell us what has been done to correct that serious trouble, which has to be overcome to make the drive successful.

Chairman Masury:—Is it not true that we have many worm-drive axles in four-wheel vehicles that heat up also?

Mr. Scaife:—I do not know; we have none.

A Minimum Axle-Spacing Limit Preferred

D. C. Fenner[10]:—With respect to restrictions, Mr. Favary advocates that the two rear axles should not be spaced farther apart than 4 ft. I should like to submit that what we want in legislation is a minimum rather than a maximum restriction. Experiments thus far made show that, within the limitations of 3 and 10 ft., there is no appreciable variation in road pressure. So far as constructional details are concerned, we certainly have rather definite limitations set by wheel diameter. I think it is unwise at this time to advocate a maximum axle-spacing. We must provide sufficient clearance for snow chains and other traction devices that may be attached to each of the driving wheels. To limit the maximum axle-spacing by law would restrict the engineering development of six-wheelers.

Mr. Favary refers to the recommendations of the

[10] Manager, public works department, Mack Trucks, Inc., New York City.

County Supervisors' Association of California and mentions only the recommendations in regard to gross load, but in the abstract of his paper, which was sent out a fortnight ago, wheel-weight restrictions were mentioned also; and it is noteworthy that the County Supervisors of California next year are going to recommend one wheel-weight restriction for a four-wheel vehicle and another for a six-wheel vehicle. It strikes me that is a bad precedent. Assuming that we can adopt a reasonable wheel-weight restriction, should it not be applicable to all vehicles irrespective of the number of wheels? That is, if a given uniform wheel-weight restriction is good for the road, should it not be equally good whether the vehicle has four, six or more wheels?

DAY BAKER[11]:—I think it is highly undesirable to specify the maximum distance between the rear wheels, for this reason: in endeavoring to secure legislation in the different States, the question of the semi-trailer is tied up with the six-wheel vehicle, and any law passed would have to admit, not only the six-wheel vehicle as described by Mr. Favary and Mr. Hendrickson, but also the six-wheel vehicle as constituted by the semi-trailer unit. Therefore, we should specify the minimum distance between the rear wheels and not the maximum. This would make any laws that are passed more satisfactory to the greater number of users of motor-vehicles and to the manufacturers in general.

MR. FENNER:—In this discussion of the relative advantages of the six-wheeler and the tractor-semi-trailer, we must remember that the six-wheeler is a single-vehicle unit, while the tractor-semi-trailer is a combination of two vehicular units.

[11] Chairman, legislative committee, Massachusetts Automobile Dealer and Garage Association, Boston.

Passing of the Rotorship

THERE is general regret, but no surprise, over the announcement that the rotorship Buchau is to be converted into an auxiliary schooner. The vessel was the experimental ship fitted in Germany with two large rotating cylinders or towers, the action of the wind on which gave the craft a forward or backward motion in accordance with the direction in which the towers were rotated.

In theory, there was little to be said against the idea, but that little was so important as to strike at the very basis of the usefulness of the design. There is a law in dynamics under which a cylinder rotated rapidly, not by the wind but by a motor of its own, moves at right angles to the wind which is striking it. It was, therefore, a simple matter to erect two such cylinders on a ship, and to prove that the ship would be carried along by the cylinders. But the weakness of the theory when applied to practical navigation is that it is only thoroughly effective when the wind is coming at right angles to the line of the vessel's course. Wind from right ahead or right astern tends to make the vessel move by the broadside, and between this extreme and that represented by a right-angle wind there are gradations of effective power varying upward from nil. It follows, therefore, that the rotorship must tack like a sailing vessel except when she has a "fair" right-angle wind (and even that of considerable strength), and that she is heavily handicapped by being quite unable to take advantage of a wind which is dead astern, and with which a sailing vessel would fly along at a great speed. She requires an auxiliary engine and propeller even more than an ordinary sailing-ship does, as she is helpless in a greater variety of conditions.

There may be a future for the rotor in some specialized branches of work, but it is quite evident that there is no future for it in ocean navigation. The best of sailing ships are now outclassed by mechanically propelled craft, and the rotorship is nothing like so good as a very ordinary sailer. As a big mechanical toy, demonstrating certain dynamic principles, it was interesting; but not much more can be said in its favor.—*Modern Transport* (London).

United States Route No. 40

WESTWARD, in the path of empire, along routes traversed by the pioneers of America from the Atlantic to the Golden Gate, and including, in the Ohio Valley, the longest stretch of practically straight road in the Country, United States Route No. 40 crosses 14 States and offers to the transcontinental motor tourist a panorama of the mid section of the Country that epitomizes the westward expansion of the Nation from colonial days to the present.

From its eastern terminus at Atlantic City this highway follows for 3205 miles the same course as, or one closely parallel to that of, the earliest settlers of the Ohio, Mississippi, and Missouri Valleys. It touches on the two great gold-fields of California and Colorado which accelerated so greatly the settlement of the Western half of the continent. It traverses also the Mormon settlement in Utah, the great agricultural experiment sponsored by Brigham Young.

From Wilmington, Del., to St. Marys, Kan., the highway is paved for the full distance, 1234 miles. From Salt Lake City to San Francisco, 890 miles, it is surfaced. Less than 14 per cent of its length is unimproved. This road runs a central course through the Country. East of the Rockies it is passable the year round. In the passes of the Rockies and in the Sierras it has not proved feasible to keep the road open in the winter, and the route is not to be depended on from Oct. 15 to April or May.

Federal aid has played a large part in the improvement of this road. The United States Government has contributed nearly $18,000,000 to the improvement. Federal-aid projects on this route include 700 miles of pavement, 725 miles of surfaced road, 132 miles of graded road, and more than 4 miles of bridges. Although not yet completely improved, the highway is everywhere in passable condition except when blocked by snows in the mountains.—*Motor Travel.*

Fleet-Superintendent Qualifications

By Donald Blanchard[1]

Transportation Meeting Paper

> The real job of the motor-vehicle superintendent is not entirely of a technical nature, although this phase of his work covers a broader scope than is generally appreciated and perhaps occupies a major portion of his time. In addition, however, he has some very important human problems to solve, and these involve not only the men subordinate to him but also his contacts with his superiors. Because of these varied factors, the fleet superintendent must combine generous proportions of diplomacy and salesmanship with his technical ability. Unless he carries on his work diplomatically and is a good salesman of his ideas, his opportunity to develop his job to the maximum and to progress personally is seriously limited.

IT is difficult to discuss the fleet-superintendent's job in other than general terms. The job itself varies even in different lines of business and among different businesses in the same line. It may stop with maintenance and only sufficient indirect control over operation to prevent continued abuse, or it may include entire control over both operation and maintenance or anything between the two extremes; so, in following this discussion, it should be remembered that every superintendent will have some but not necessarily all of the responsibilities listed.

The superintendent's job calls for keen business judgment, broad engineering knowledge, a practical understanding of accounting, some acquaintanceship with the law, an appreciation of the principles of scientific management and the ability to handle personnel. In analyzing some of the details of the job the conclusion is soon reached that the superintendent faces nearly all the problems that confront the general manager of a manufacturing plant. The job has so many varied aspects, technical and otherwise, that it is puzzling to know where to begin.

The purchase of rolling stock is an engineering problem that may be and often is more difficult than the one the factory executive faces in buying a battery of machine-tools, and the amounts of money involved in the two cases are comparable. Sometimes something entirely new must be designed to meet operating requirements exactly. In other cases, expensive alterations to buildings may hinge on the decision.

Next comes the purchase of bodies, which bear somewhat the same relation to the motor-truck or motor-coach that jigs and fixtures bear to machine-tools in the manufacturing field. The body builder is a big help here, but the superintendent must be competent to pass on the structural strength of the design and its suitability for the purpose. Here again he may have to step out into new fields to get the exact answer, which may call for considerable inventive skill and engineering ability. In addition, in some fields, such as the public-utility field, the truck engine serves as a traveling powerplant which operates machinery of various kinds. The design and installation of this machine equipment must be along sound engineering lines, and the superintendent is the technical authority on whom his employer relies.

Incidentally, the superintendent must be familiar with all the legal requirements in force in the jurisdictions in which his equipment will operate, which brings him into the field of law. Moreover, he must keep in touch with all proposed legislation in these jurisdictions so that he can oppose that which is objectionable.

Loading and unloading methods have an important bearing on costs and the superintendent has to give them the same engineering consideration that is given to material-handling methods in the factory. Routing, or despatching, also requires analytical study as it involves traffic conditions, loads to be carried, seasonal fluctuations and other considerations. To indicate how complex this matter may become it is necessary only to mention that in some lines, such as the department-store business, maximum-transportation requirements may be 100 per cent or more above the normal. It is no simple task to devise a routing system that is flexible enough to meet such a fluctuation. In addition, where such large variations are encountered, the superintendent must determine the most economical size of the fleet; that is, how many vehicles his company should own and how many it should hire during extreme peaks.

In regard to maintenance, it is sufficient to say that the superintendent must call on his knowledge of engineering and management principles at every turn. He must schedule the work so that it can be accomplished with the minimum of interference with operation, and at the same time try to provide reasonably continuous work for the men. Routing, inspection and lubrication must be provided for at just the right intervals because, if this work is done too frequently or not frequently enough, costs rise. In some cases special routines may be necessary for certain vehicles or groups of vehicles because of operating conditions. The same sort of consideration also must be given to major maintenance-operations. The work must be planned so that repairs will cause the minimum of lost truck-time. This may require night repair-service or the adoption of the unit-replacement system.

Decisions must be made as to what work shall be done

[1] M.S.A.E.—Editor, *Operation and Maintenance*, Chilton Class Journal Co., Philadelphia.

in the fleet shop and what shall be farmed out. In making these decisions, maintenance costs are not the only consideration because allowances must be made for the relative speeds with which the work can be done in the fleet shop and elsewhere so that the minimum of idle truck-time will be rolled up. In the light of these decisions, shop equipment necessary to the efficient performance of the work to be done in the fleet shop must be selected. In addition, the superintendent occasionally is called upon to design maintenance and storage buildings, and this takes him into the field of architecture.

The superintendent is also a storekeeper, as he must keep a sufficient stock of parts and supplies to assure continuous operation; but the investment in these materials must be kept at the minimum and, to accomplish this, he must familiarize himself with local sources of supply. He may also find it desirable to check the quality of certain materials he buys, and this may involve laboratory tests. Therefore, the superintendent must be able to interpret the significance of the laboratory reports. Considering the broad range of supplies and equipment which are required for fleet operation, it is evident that the superintendent must be a buyer of no mean ability.

Cost Records Essential

Although the cost keeping is usually done by the accounting department of the operating company, the fleet superintendent needs some records for his own day-to-day control of performance. He also advises with the accounting department as to what records it should keep and how it should keep them, what information it should send to the transportation department at regular intervals and the like. On occasion, the superintendent may find it desirable to keep check records for a short period to test the accuracy of the accounting-department reports, or he may feel that some cost element is too high and keep a short-time split-up account on this expense until the condition has been rectified.

The superintendent has the same personnel problems in connection with the shop that are found in a manufacturing business and, if he is charged with the selection, training and control of drivers, an even more difficult problem faces him. The driver on the road is not subject to direct control and, if results are to be obtained, the superintendent must create a correct mental attitude among the drivers, this being obviously not an easy thing to do. In an experimental way, at least, the driver question is bringing some fleet operators into the realm of psychology as attempts are being made to develop standard tests which will assure the selection of good drivers.

Intangible Elements also Important

Only the general features have been covered in the foregoing, no attempt having been made to go very deeply into detail. My intention has been simply to indicate the many complex problems with which fleet superintendents are coping successfully and to picture the breadth of information which the superintendent must have at his command. This is the job in its technical and more tangible aspects. It has some less tangible aspects, however, which are of even greater importance. In fact, the opportunity for progress which the job offers is determined to a considerable extent by how well these less tangible elements are covered.

Motor-vehicle transportation is a fast-moving business and it needs the leadership of fast-moving minds. While nearly 3,000,000 commercial motor-vehicles have been placed on the highways in a relatively short time and we have come a long way in our understanding of how best to apply and operate them, the job is not yet finished. We are still in a stage of rapid development, and it is likely to be many years before we shall have the experience that is necessary to take the fullest advantage of the capabilities inherent in the motor-vehicle.

The annual cost of operating a large fleet of motor-vehicles can easily run into six figures, and there are more than a few instances in which it runs into seven figures. These are huge sums of money and represent an important element of the operating company's cost of doing business. As the company's buyer of transportation, the responsibility rests, or should rest, on the fleet superintendent. It is a big job to spend this money effectively, and it should be recognized as such by management; but, as in every other line of activity, the bigness of the job depends to a considerable extent on the man who occupies it. Responsibility has a habit of going where it is received with open arms.

In a business that is developing as rapidly as is motor transportation, the open mind is an invaluable attribute. One might think that this quality would be rather common among human beings; but, in fact, it is a relatively rare quality and no one ever attains perfection in it.

Maintaining this open-minded mental attitude is an essential part of the real job of the fleet superintendent. Having an open mind does not mean that the new or the different thing is accepted simply because it is new or different; rather, it means a receptive attitude toward the new or the different thing, an attitude that permits unbiased consideration of an innovation or a departure from previous practice. The open mind does not reject the new or the different thing with an automatic "That may be all right for him but it would not work under my conditions."

In several instances when attending conventions I have tried to estimate what the attitude of particular individuals in the audience was to the ideas presented by the speaker. One such occasion comes to my mind particularly. At a meeting of service men, a man who has used the budget system in managing his shop, with outstanding success, was discussing budgetary control. The general attitude of the audience was that budgetary control is a lot of red tape, and this was politely but plainly indicated in the discussion which followed; but, within a year, some of those who had expressed adverse opinions were operating their own shops under budget systems. In each case the owner of the business had said: "We are going to have a budget." Now that they have the budget, these same men are among its most ardent proponents. How much better it would have been for these men personally if they had supplied the impetus toward the adoption of the budget rather than having it shoved upon them by the boss. If their attitude at the meeting referred to had been open-minded, the possible additional worry and detail incident to the operation of a budget would not have obscured its positive advantages.

Recently, a fleet superintendent of my acquaintance made a drastic change in his maintenance methods which has now resulted in very large savings. This change was the product of an open mind which had the

(*Concluded on p.* 60)

Power-Transmission Engineering

Discussion of W. W. Nichols' Production Meeting Paper[1]

POWER-TRANSMISSION equipment should not be regarded as a necessary evil, according to Mr. Nichols, but as a valuable aid to production. Attention from the management is needed to encourage improvements, and careful record-keeping and accounting will help to locate leaks in maintenance cost.

Installation and maintenance of such equipment should be in charge of a progressive and intelligent man, who will substitute scientific information for rules of thumb.

A testing-motor outfit for checking the power required for shafting and machines is described, and examples of wattmeter records are given. Charts are included that show the power required for removing stock in a machine-tool at various rates and to show the power that should be transmitted by fabric and leather belts of various sizes at any speed.

The paper also includes a number of hints in regard to inspection of belting and for dealing with specific conditions affecting the operation of belting.

Mr. Nichols' recommendations are endorsed in the discussion by several members, one of whom cites savings totaling as much as $1,000 per day for belting alone in a single plant.

Charts and formulas for determining the power required for removing metal are discussed. It is admitted that they cannot be applied blindly, but they are at least a good aid, to a man who can use them with judgment, in estimating average requirements.

L. A. BARON[2]:—Power transmission comes to the accountant in dollars and cents. Mr. Nichols has said that, unless costs are segregated and separate accounts are opened for such items as new installations of belting, belt maintenance and repair, lubrication, and repairs to transmission lines, it is not possible to check up on them when the cost sheets are made up at the end of the cost-accounting period.

I wonder how many production men realize how important it is for them to work with their cost men, helping them to compile their cost figures. Only a few charges to blanket accounts in a day will amount to many dollars in unaccounted-for costs; then someone wonders why costs are going up.

It has been my experience that the only way the production man can reduce his costs is to know what the costs cover. If I tell a man that it costs $1,000 to run his department for a week, that means nothing to him; but, if I can show how the $1,000 is made up of definite items of 10 cents to $100 each, I have given him something with which he can start to cut down on the individual things. It should be easy to segregate the costs on the different items of expense in a department.

I realize that production men meet many problems every day. If you are in charge of a department in the shop, you may have from 50 to 500 men under you, all asking questions and running after you, and the general manager wants a certain number of units every day. These units cannot be produced without paying out money, and you who actually spend that money should be able to keep a record of what the money is spent for. If your cost man is not providing the segregation enabling you to charge expenditures properly, get him to do it for you. If he is worthy of his job he will do that; and, when he gives you the reports, use them.

I will cite a case in our own shop, where budgeting the individual departments was begun on Jan. 1, 1928. The foreman in charge of car shipping came to me one day tearing his hair, and when he got through ranting I discovered that it was all about a charge of 47 cents that did not belong on his account. He had analyzed every item on the cost sheet I had given him and found that all the other charges were correct; and he made me cross off the 47-cent item, at a cost of about $1 for clerical work.

Possibly 15 days later, the general manager asked me how the men were taking to the budget plan, and I cited this case. He asked the man's name and watched him. That foreman reduced the cost of loading cars 50 per cent in about 90 days, just by studying the items that went to make up the costs of running his department.

It strikes me that the managements of well-organized plants today are taking the attitude that they have reduced direct labor nearly to the minimum without cutting the earnings of the individual worker. There is a tremendous tendency to focus attention on the reduction of overhead costs, and power transmission is one of them. The production man who will stand head and shoulders above his fellows is the one who can reduce the overhead costs, and the only way to do that is to find out what they are for.

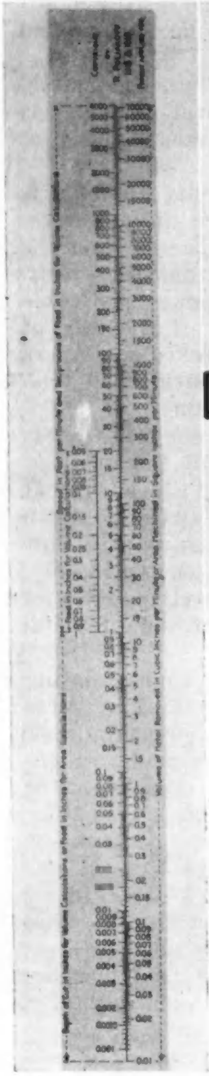
SAVING $1,000 PER DAY

A. F. DENHAM[3]:—One company, which produces about 1200 engines per day when at its peak production, started to work on this subject about 1924. I was at its plant recently to find out how much progress had been made in cutting the costs. In 1924, the company actually was spending $1 per engine for belting. During the last year, the cost has been 23 cents per engine, making a saving of about $1,000 per day during maximum production.

[1] Published in the S.A.E. JOURNAL for December, 1928, p. 557. The author is a member of the Society, and vice-president and mechanical engineer of D. O. Brown & Co., Detroit.

[2] Comptroller, Stutz Motor Car Co., Indianapolis.

[3] Field editor, *Automotive Industries*, Detroit.



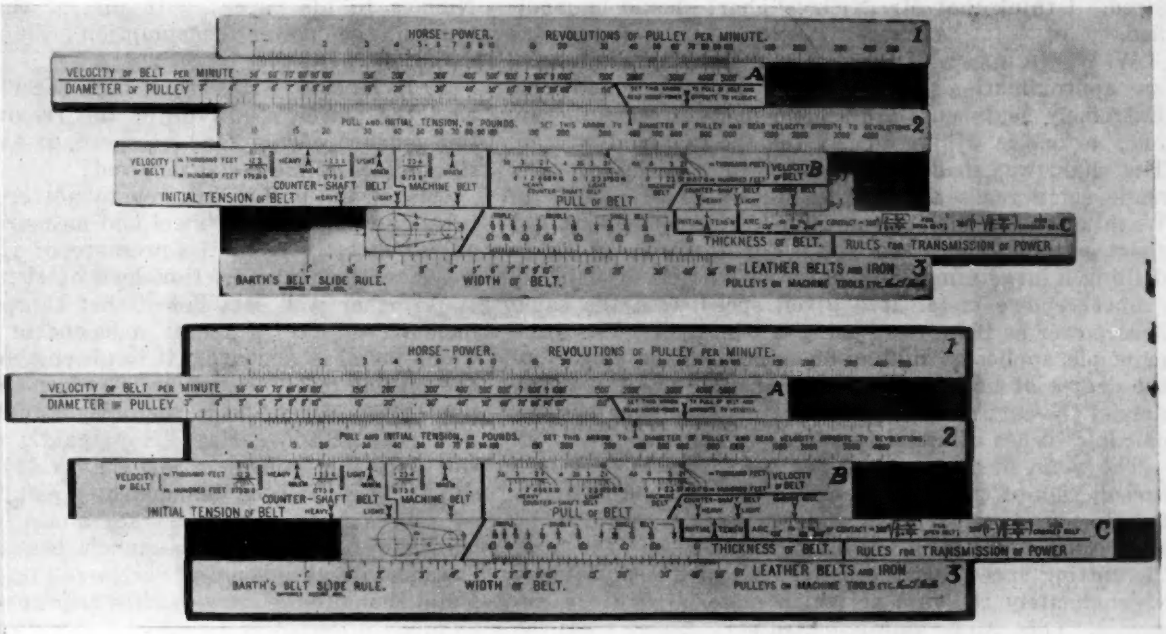


Fig. 1—(Left) Poliakoff Scale for Metal Cutting

This Scale, the Operation of Which Is Explained in the Text, Is an Aid in Computing the Rate at Which Metal Is Removed in Turning

Fig. 2—(Above) Barth Slide-Rule for Belting

Many Factors Affecting the Power That Can Be Transmitted by a Belt Are Given Places on This Slide Rule, the Operation of Which Is Explained by Mr. Nichols in the Text

There is no reason for stopping with belting, although that probably is the largest single item on which costs can be reduced. The cost-reduction possibilities on non-productive materials in general certainly are tremendous. This same company was spending about 28 cents per engine produced for ordinary hand-files in 1924. Its research department, organized to study belting and other non-productive materials, was put to work on this, and in 1927 the cost of files was only 8 cents. Real savings are possible even on an insignificant item like rags, which cost 32 cents per engine in 1924 and 15 cents in 1927. This department is working on well over 100 such items, so you can see that the savings will mount up in the long run.

L. A. Churgay[4]:—Some time ago, in analyzing non-productive-material expenses in our plant, we noticed that one of the largest single items represented belting for power transmission. An investigation revealed that existing conditions offered an excellent opportunity to effect economies in this line. We have instituted a special study of belting requirements and standards, and have extended these activities to include other non-productive items such as perishable tools, lubricants, grease, oils and supplies. The result of our first year's campaign has been a saving of $100,000, and we feel that the field is so great that we scarcely have scratched the surface as yet.

[4] M.S.A.E.—Plant equipment engineer, Chrysler Corp., Detroit.

[5] M.S.A.E.—Production engineer, Continental Motors Corp., Detroit.

[6] M.S.A.E.—Chief mechanical engineer, Kearney & Trecker Corp., Milwaukee.

A. R. Fors[5]:—Like everyone else, we have been hammering on direct-labor costs for many years, but about a year ago we woke up to the fact that we were spending a great deal for non-productive materials, maintenance and other overhead items, as well as for direct labor. Now we are doing a great deal of work along the lines that have been discussed, and during the year just passed we have made a substantial reduction in maintenance cost through educational campaigns among the foremen and the men, together with standardization and reduction in usage of non-productive materials.

Power Required for Removing Metal

J. B. Armitage[6]:—Mr. Nichols' straight-line chart for determining the horsepower required for removing metal means little without qualification. If you cut with a knife through the middle of a loaf of bread 5 in. square and 10 in. long, you remove 125 cu. in. of bread. If you cut the bread into ¼-in. slices instead, 20 cuts are required to remove the same amount of bread. No one would say that the same amount of effort is required to make the one cut as to make 20 cuts. The power required for removing metal cannot be determined without taking into consideration the thickness of chip.

Many other factors also affect the power required. Cast iron is not the same before and after the scale is removed, and one lot is entirely different from another. Material cannot be removed from a part that requires a very fine finish with the same horsepower and rate as if a thick chip could be taken; it is exactly the same as cutting the bread. In making tests on our production-service machines as they leave the floor, we take many horsepower charts, and find that the horsepower varies far more than 2 or 3 to 1 according to the finish de-

sired. I think that Mr. Nichols' chart should be modified.

W. W. NICHOLS:—The purpose of that chart is to give an approximation for ordinary working conditions. Extremely heavy cuts are seldom made in manufacturing; no one is willing to pay for the material wasted. The chart was made on the basis of a series of tests made some years ago at the Bureau of Standards in Washington. A man can get into trouble if he uses the chart without some thought. For instance, if he is drilling a large number of holes with a No. 60 drill, he cannot remove metal at a given speed with the same horsepower as if he were using a 1-in. drill. The same principle applies to milling-machines, and it applies to the degree of finish, the amount of scale and the thickness of the cut; it is not entirely a matter of the number of cubic inches of metal removed per minute.

The main idea is to take the belt problem from the jurisdiction of the old-time millwright and put it under the time-study department and the plant engineer. The time-study department knows the depth of cut, the feed, the cutting speed and the material, and it should know approximately the rate at which material is to be removed. This can be approximated very closely from the first three items by means of the Poliakoff scale, to which reference was made in the paper.

OPERATION OF SCALES EXPLAINED

The Poliakoff scale is shown in Fig. 1, and I will explain its use by an example: Assuming a cut 0.2 in. deep with 1/16-in. feed and a cutting speed of 40 ft. per minute, set one leg of the dividers at 0.2, below 1 on the scale for depth of cut, and the other leg at 16, above 1; move the lower leg to 1, and the upper leg strikes 80; leaving the leg on 80, close the dividers to 40 ft. per min.; transfer to 1 the leg that is on 80; and read in the right-hand column, 6 cu. in. per min. of metal removed. Should the cutting speed be changed to 120 ft. per min., the dividers would be set for the distance between 80 and 120; and, because 120 is above 80 on the scale, the final reading in the right-hand column would be above 1 instead of below, when the leg on 80 is moved to 1.

The operation of the Barth slide-rule is as follows: To determine the power transmitted at 1000 ft. per min. by an 11/16 x 6-in. belt with 180 deg. arc of contact, set the 11/16-in. graduation on slide *C* over the 6-in. graduation on scale 3, as shown in the upper view of Fig. 2; move slide *B* so that the arrow for the machine belt is over 180 deg. on slide *C;* set the arrow of slide *A* opposite a machine-belt speed of 1000 ft. per min. on slide *B* and over a 1000-ft-per-min. belt-speed; then, on slide *A*, read 20 hp. on scale 1 for the power transmitted. If the index for the machine belt is set at 160 deg., as in the lower view, the reading will be only 18½ hp., a loss of 1½ hp. for the change of 20 deg. in arc of contact.

FACTORS AFFECTING POWER REQUIRED

MR. DENHAM:—Some time ago I checked up on the various horsepower formulas used by machine-tool manufacturers for cast iron, and found that the results vary from 0.2 to 1 hp. per cu. in. per min., while the formulas for steel give results of from ½ hp. to well over 2 hp. After all, the answer is indicated by Mr. Nichols in his paper; with one of the testing-motor trucks, the power consumption can be determined definitely.

F. L. MORSE[7]:—Has it not been ascertained definitely that the power required for the removal of metal is independent of the feed or speed, if taken directly at the surface of the metal removed?

One of the problems given to university students is to turn a small bar of steel and measure the power required directly from the pressure of the tool and the speed, without the friction load of the machine itself. It is rather well established that the power per cubic inch per minute is almost independent of the rate at which metal is removed. It has been checked on planers and milling-machines, which introduce considerable friction that is not found in the ordinary lathe.

MR. ARMITAGE:—May I say that is not true unless you take into consideration the average thickness of chip? This has been demonstrated many times. To cut two slices instead of one takes almost twice as much horsepower—not quite that much, because in steel, for instance, it takes some power to roll up the thick chip. Metal that breaks away readily requires virtually twice as much horsepower to cut the same amount of metal into two chips as to remove it in one.

There is a rule-of-thumb method for approximating what might be called good practice in milling or turning or removing metal in any way; the horsepower per cubic inch per minute is very nearly the same by whichever method metal is being removed. If you know the efficiency of the machine—which may be as low as 30 or 40 per cent or as high as 75 or 80 per cent or more—it can probably be said that you can remove 1 cu. in. per min. of ordinary 1020 S.A.E. steel and 1¾ cu. in. of ordinary cast iron with 1 hp. But, if you are removing only sufficient metal to get a finish, it is not being removed at the most economical speed or feed and the formula does not apply. In addition, very few men know the efficiencies of the various machines.

A. C. WOODBURY[8]:—Is not the comparison of a cutting-tool in steel or cast iron with a knife cutting bread a little unfair? We do not use a tool of a comparable shape, unless it is a hack-saw, with which it is just as easy to cut off 6 in. as ½ in., as with a knife.

MR. NICHOLS:—This discussion is leading up to a point that I intend to bring up at the next meeting of the committee of the American Society of Mechanical Engineers on the cutting of metals, of which I am chairman. That is, the necessity for investigating cutting angles of tools for use in alloy steels. Most of the tools used today are being ground to the angles recommended by Frederick W. Taylor, and he had no alloy steels with which to experiment in determining those angles. Experiments are being conducted in one of the universities to determine the correct size of tool bites and the distance they can project beyond the tool-holder.

W. A. BLACKBURN[9]:—The common policy of using small motor-pulleys, with the resulting small arc of contact, seems to be wrong. Some improvement ought to be made by the machine-tool makers and the electrical manufacturers to avoid the excessive consumption of leather belting caused by this practice.

MR. NICHOLS:—The machine-tool manufacturers are not to be blamed for using such small pulleys; the blame belongs to the manufacturers who prefer to buy high-speed motors because they are cheaper.

(*Concluded on p.* 72)

[7] M.S.A.E.—President, treasurer, Morse Chain Co., Ithaca, N. Y.

[8] M.S.A.E.—Editorial department, Society of Automotive Engineers, Inc., New York City.

[9] Mechanical engineer, Chrysler Corp., Detroit.

Selection of Speed Reducers for Conveyors

By C. E. Broome[1]

Production Meeting Paper *Illustrated with* Photographs

CONVEYORS operate at such slow speeds that a great reduction in speed is needed between the driving motor and the head sprocket of the conveyor. To secure this, it is customary to use a speed-reducer unit.

Of the several types made, each has a field in which it is best. Single or double gear-reductions are suitable for small reductions, bevel and worm gears turn right angles, and the concentric-shaft type gives great reduction in a compact unit.

The general requirements of a drive will point to the use of one of these types. Full specifications should be sent to manufacturers of units of that type, and the proposals submitted will make it easy to select the unit best suited to the particular job.

During the discussion, Mr. Broome replied to questions with information as to when right-angle drives are preferable, the relative efficiency of reducers of various types in different ratios, and the losses to be expected in the most efficient types.

METHODS of production, as well as the better and more beautiful automobiles produced, have played an essential and important part in building up the automobile industry. Methods of production that make possible a continuity and at times a multiplicity of operations have enabled manufacturers to place automobiles on the market at prices that represent a dollar value in excess of many other standard commodities.

The labor savings that have been accomplished through material-handling equipment are many, and for this reason conveyor systems are in universal use in automotive plants.

The selection of the correct driving units for conveyors must be controlled in virtually all cases by a study of the conditions under which the conveyor is to operate, the space limitations, and the loads to be carried.

With the exception of gravity systems, all conveyors require some method of power transmission. The speed of the conveyor, or of the material, varies infinitely, and for this reason some means of controlling the speed is required.

Space is valuable, and any design of installation that makes possible a compact unit assembly commands consideration. Electric motors are manufactured to run at standard speeds that usually are too high for direct connection to the conveyor. For this reason an interpolated speed-reduction is imperative. The most common way of securing the desired speed is through a speed-reducer unit.

Speed reducers of enclosed types, with gears and bearings operating in a bath of oil, offer means of power transmission that promise to the plant engineer the minimum maintenance. Limitations of space, efficiency and adaptability virtually eliminate the use of open gearing.

Under different conditions, one or another type of speed reducer may be preferable. This is nearly always because of space limitations or installation requirements rather than because of load capacities or operating conditions.

Each manufacturer of speed reducers may have one particular type, such as the spur, planetary, bevel, worm or herringbone-gear type, on which he has done considerable development work, and as a consequence he specializes to a certain extent on this type. It is generally conceded that almost all of the speed-reducer manufacturers endeavor to produce a superior product; the final choice therefore should depend on the applicability of the reducer to the conveyor installation.

Most of these installations are designed with a variable-speed transmission between the motor and the speed reducer. The connections between the variable transmission and the speed reducer and between the speed reducer and the conveyor may be direct, or through gearing or a roller chain. Economy in both initial cost and maintenance favors the roller chain.

An analysis of the various types of reducer shows that the spur-gear compound reducer has certain advantages for ratios within its limits, and

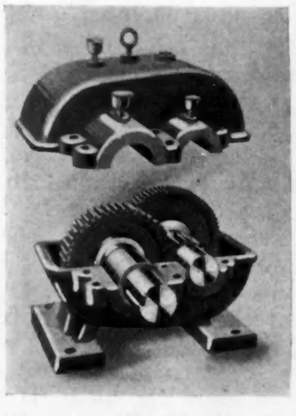


Fig. 1 — Simple Spur-Gear Reducer

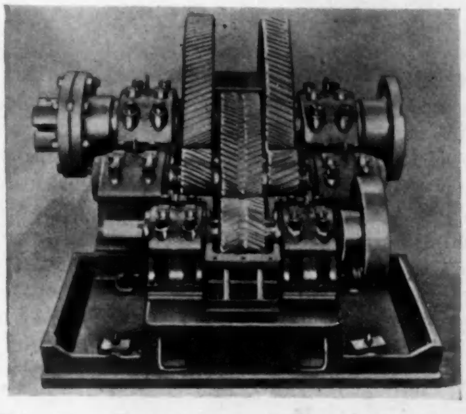


Fig. 2 — Herringbone-Gear Double-Reduction Unit

[1] A.S.A.E. — Sales engineer, Gears & Forgings, Inc., Cleveland.

the cost of such units, within these limits, may be less than that of other types. They usually are built with input and output shafts parallel.

Herringbone gears, when applicable, provide the ultimate refinement of the single and compound types of gear reducer, like those shown in Figs. 1 and 2. They provide smooth drive, with the assurance of uniform angular velocity. Such gears have solved the problem of driving the rolls of sheet mills. The disadvantages of reducers of these types are that they usually are not so compact as some others, and it usually is not practicable to balance the design for the higher ratios.

Right-Angle Drives Are Compact

The worm-gear unit, as shown in Fig. 3, is an ideal type of right-angle drive and is being produced by several manufacturers as a very efficient drive. This type has had considerable prejudice to overcome, largely because of meager and contradictory information in text-books. Reliable information regarding efficiency and design is now available, however, and a steady increase in the popularity of the worm-gear speed reducer may be expected. Minimum and maximum ratio limitations in this type of unit for most successful operations are about 8 to 1 and 50 to 1.

The worm-gear unit operates to best advantage when coupled directly to the motor. Such units have been used extensively as head-shaft drives in elevator-type conveyors because of the irreversible feature. Irreversibility was an inherent quality only because of inaccurate manufacture and inefficient bearings, and belief that it exists with the present quality of drive is more or less of a fallacy. A brake should always be provided for an elevator conveyor, as it undoubtedly will be found necessary with an efficient reducer.

The bevel-gear reducer is a type of right-angle drive that is very adaptable in ratios between 2 to 1 and 8 to 1. If a higher ratio is desired, it is necessary to supplement the bevel gears with spur gears, as in Fig. 4. Different manufacturers are furnishing this type of drive in ratios up to 200 to 1.

A spur-gear concentric-shaft speed reducer may be composed of a compound series of spur-gears or may utilize an internal gear. It may or may not be of the planetary type. This concentric-shaft type has found the greatest favor in the conveyor field.

The driving pinion of the compound type engages with at least three gears, distributing the load and making possible a very compact design. The non-planetary internal-gear type has the idler or intermediate-pinion shafts held in a fixed position by the frame, and the internal-gear ring is mounted on bearings and drives the slow-speed shaft. The planetary internal-gear type has a fixed internal-gear ring, and the slow-speed shaft is driven from the plate carrying the idler or planet gears. A compound planetary reducer is illustrated in Fig. 5.

A common hook-up for conveyors is from the motor to a variable-speed transmission and from the variable unit to the speed reducer by silent chains, and then through a roller chain from the reducer to the head-sprocket of the conveyor. The concentric-shaft type of reducer lends itself admirably to installations of this kind.

Standardization and Adaptability

Several other things besides type are, however, to be taken into consideration in choosing a speed reducer for a conveyor drive. In a field in which the product is so highly standardized as in the automotive industry, it is appropriate that plant equipment shall be standardized, for interchangeability of parts as well as of complete units. It is also well to investigate the possibility of ratio changes and increased stresses, because of either increased speeds or increased loads.

The load to be carried on any conveyor can be expressed in pound-inches torque at the conveyor head-shaft, and the reducer should be chosen according to this figure. An analysis of design of a well constructed speed-reducer usually shows the slow-speed shaft to be the weakest member; consequently the torque capacity in pound-inches at this point determines the load-carrying capacity of the unit. Some manufacturers give also a rated capacity for chain pull, in pounds; but this should be a secondary consideration, as it is merely a bearing load.

The torque load in pound-inches can be translated through the gear ratios to give the motor requirement, taking into consideration whatever efficiency losses there may be.

Speed reducers sometimes are given a higher rating for intermittent loads than for continuous duty; but, if they are used for starting under load, they should be chosen under the same rating for intermittent as for continuous service. If peak loads or jams are likely to occur, an allowance should be made for them. Speed reducers are rated by most manufacturers with a 100-per cent overload capacity, but this extra capacity sometimes is used without an abnormal overload being placed on the conveyor itself, because of installation conditions.

When it is necessary to increase the speed of the conveyor, it is advisable in nearly all cases to make the change at the input end rather than to change the drive between the reducer and the conveyor. This is because a more liberal factor is used on the design of the high-speed end than in the rest of the reducer. This may seem inconsistent, but numerous breakdowns have occurred in practice from placing on the slow-speed shaft a larger sprocket than the original design of the installation required.

Availability for Various Uses

Another fact to be taken into consideration in selecting a reducer is that its life is likely to exceed the period that any certain procedure of operations will be in use. Therefore the reducer chosen should be adaptable to other installations with the minimum of constructional change.

Further, it is desirable to select reducers of a type and design that can be used in as many different installations as possible. This will permit the carrying of the minimum stock of parts and units for repair and replacement.

Speed-reducer manufacturers are not always entirely familiar with every kind of installation, and at times they have sold their products for duties that were far beyond the capacity of the reducers. This may have been because of over-selling by a salesman, or to choosing a reducer from horsepower rating only.

If a sprocket or a gear is to be mounted on either the input or the output shaft, it is well to ascertain whether the reducer bearings at these points are of sufficient capacity to carry the load. If they are not, it will be necessary to decide whether the use of outboard bearings is practicable. Speed reducers having antifriction

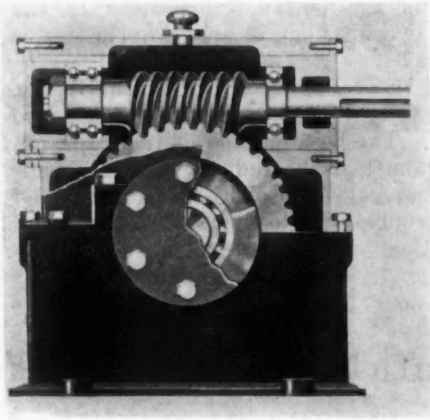


FIG. 3—WORM-GEAR SPEED-REDUCER

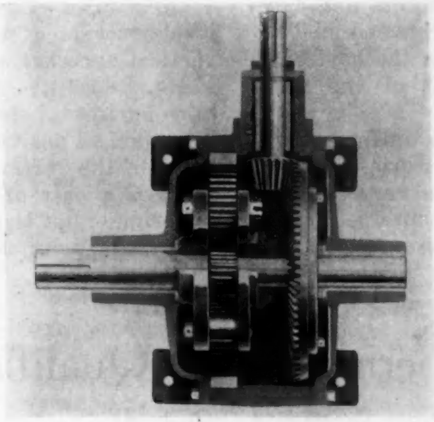


FIG. 4—COMBINED BEVEL-GEAR AND PLANETARY UNIT

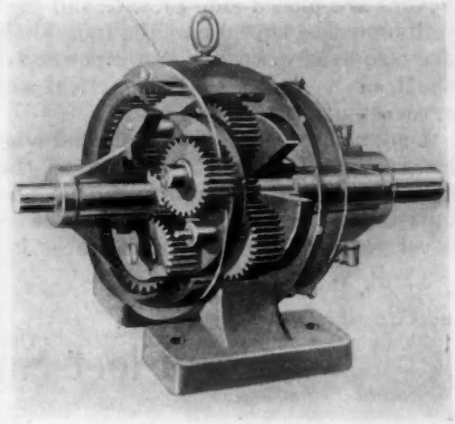


FIG. 5—COMPOUND PLANETARY SPEED-REDUCER

bearings at these points are best suited to carry over-hung loads, and it is nearly always advisable to use out-board bearings if the high-speed and low-speed bearings are of bronze or babbit.

Compactness demands that alloy steels be used for all of the moving parts and precludes the possibility of using any but the highest grade materials in a well-designed speed-reducer. While compactness is very desirable, it should not be gained at the expense of effective lubrication or an oil reservoir of sufficient capacity.

LUBRICATION AND PURCHASING DATA

The reducer chosen for any application must be easily lubricated, and the drain plugs should be accessible and in a position such that the unit can be drained into a receptacle; not onto the floor. Oil-level cups, plugs or gages should be located so that the oil level can be observed and checked easily.

The greater the number of factors taken into consideration in the choice of a correct power-unit, the more it will be apparent that some one type of construction will give the most efficient service. Manufacturers of equipment of this type should be given full information as to the installation, such as torque at head-shaft in pound-inches; ratio of reduction and method of transmission desired between reducer and head-shaft; input and output speed in revolutions per minute; and possible peak loads. If the reducer is to be mounted in a location where the temperature differences are considerable, this should be noted.

If these points are kept in mind, the recommendations made will be for the best equipment that the various manufacturers have to offer for the particular problem, and the buyer can be assured that, from those recommendations, it will be a simple matter to find the one reduction-unit especially adaptable to his needs.

THE DISCUSSION

CHAIRMAN V. P. RUMELY[2]:—Stores managers, from the consideration of material supply, like to see everything standardized as much as is practical. If a speed reducer on a small job somewhere in the plant breaks down they would like to replace it with a standardized large unit, even though it is somewhat larger than required; but there are limitations to such standardization.

N. H. PREBLE[3]:—What is the real advantage of the herringbone speed-reducer, compared with the worm-gear and spur-gear types, in small ratios?

C. E. BROOME:—I favor the worm-gear type for high speeds and light loads, because it is easy to make a drive of this type more compact than a herringbone unit. Also, there is difficulty in mounting the high-speed pinion of the latter so as to prevent deflection of the shaft. If it is possible to find some means of mounting in bearings that will prevent this deflection, the herringbone is an ideal type of unit.

QUESTION :—What percentages of efficiency can be expected from speed reducers of the various types under similar conditions and with the same reductions?

MR. BROOME:—There is little variation in efficiency between the speed reducers produced by the various specialists in that line. Probably the herringbone type is most efficient in single reductions, and spur-gear and worm-gear types are about on a par in reductions up to 20 to 1. For ratios between 20 to 1 and 50 to 1, the spur-gear type has a slight advantage; and above 50 to 1 the spur-gear types—planetary or straight compound —are the most efficient, according to our tests.

LOSSES MAY BE ONLY 2 PER CENT

Losses in spur-gear reducers are about 3 per cent with a ratio of 8 to 1, which is the highest ratio ordinarily used per stage. With a 6-to-1 ratio, the losses are about 2 per cent for each stage. Worm-gear efficiencies vary in direct proportion to the ratio and depend also upon the design of the gear. The efficiency of any specific worm-gear reduction can be obtained only from its manufacturer. The efficiencies of worm-gears are not nearly equal to those of single-reduction spur-gears.

QUESTION:—Under what conditions are right-angle drives of the worm and bevel-gear types desirable?

MR. BROOME:—Right-angle drives are indicated where the room available does not make possible a convenient arrangement with other types, as where several belt con-

[2] M.S.A.E.—General stores manager, Hudson Motor Car Co., Detroit.

[3] Vice-president, Mechanical Handling Systems, Inc., Detroit.

veyors are placed side by side and the motors and drive units must be kept under the individual conveyors. They are also used in transmitting power from the horizontal shaft of a motor to the vertical shaft of the head-sprocket of a conveyor chain.

Under high-speed conditions and where uniform angular velocity is important, I favor the worm-gear. If shock loads are to be transmitted and a very compact unit is desired, the bevel-gear type is suitable, spiral-bevel gears being used if quietness is essential.

QUESTION:—How is the power transmitted to the head-sprocket of an overhead chain conveyor having a vertical sprocket axis?

MR. BROOME:—All the reducers shown in this paper have horizontal shafts; but all of them can be built also in a vertical position. The best method of transmission between the vertical shaft of the reducer and the head-shaft is a pair of spur-gears. Roller chains are used sometimes; but less trouble will be encountered with the spur-gears, with vertical shafts.

Fleet-Superintendent Qualifications

(Concluded from p. 53)

courage to carry out a radical departure. It is easiest to run along in the old rut, but this practice does not produce results in our rapidly developing field. New ideas and new methods are emerging too fast for us to become smug about the way we are doing things today.

Accomplished Improvements Need Emphasis

Selling the achievements of the transportation department certainly is another phase of the real job of the fleet superintendent. The old theory that all that is necessary to win recognition is to build a better product is not as effective as it formerly was. Something more than a good product is necessary. The sales manager and the production manager do not neglect any chances along this line. Why should the superintendent? Selling in this manner may sound like tooting one's own horn, but it can be put over without creating this reaction if it is done diplomatically. For example, painting and body maintenance-work look like just so much expense on the monthly operating-statement. But if these items are interpreted to the chief executive in terms of the fine appearance of the equipment and the favorable advertising it is giving the business, he may get an entirely different viewpoint not only of the expense but of the superintendent. In the mind of the boss the superintendent is likely to become, not merely a foreman for a gang of men in the shop, but rather one who is thinking and planning in terms of the progress of the business as a whole.

Naturally, selling the transportation department must be backed up with a record of accomplishment. The superintendent must have things to which he can point with pride. But, assuming that he has the record and fails to do a little tactful pointing with pride, he is overlooking a very real part of his job and a duty he owes to himself and to those subordinate to him. The negative things about the department get to the management without any help, and they are likely to overshadow the positive achievements unless the latter are emphasized from time to time.

Tactful Salesmanship

Salesmanship is also involved in the coordination of the activities of the transportation department with other departments of the business. Except in the case of the motor-vehicle common-carrier, the fleet ordinarily is organized to render service to other departments of the business. We all know how unreasonable these other departments can be at times, yet they are the customers of the transportation department, and apparently it is the inalienable right of customers to be unreasonable. Meeting these unreasonable demands with the minimum of friction is part of the superintendent's job in his capacity as sales manager for his department. How tactfully he handles this selling job determines to a large extent whether the other departments of the business are pulling for or against him, and it is obviously worthwhile to have them as boosters.

The business of motor-vehicle transportation is so varied in its aspects that the superintendent's job requires a broad technical training combined with good business judgment. It requires more than a superficial knowledge of accounting and of some phases of the law. Perhaps, most of all, it needs men of vision, men with flexible, alert minds. It is a real job with real opportunities, and the transportation membershop of the Society provides plenty of evidence that it is attracting real men.

The Real Scheme of Things

THE real scheme of things is one that involves every now and then a break with the past. It is a scheme of things in which the new is produced, in which novelties occur and agencies act. This is shown both by logical demonstration and by appeal to fact. Life once was not, and then it was; thinking has not always existed, but now, let us hope, it does exist; evolution has always been going on but thinking about evolution has not. Evolution itself must, then, be of such character that it allows thinking about it to appear, whereas, before, such thinking was absent. It must be of such a character as to permit the new and the novel now and then to arise.

The walls of the past can be scaled. The means thereto is reason.—Edward G. Spaulding.

Long-Haul Passenger Transportation

By W. E. Travis[1] | Transportation Meeting Paper

THE creation of additional operating divisions and maintenance units, based on the California Transit Co. system originally operated by the author, which had proved successful in long-haul passenger transportation on the Pacific Coast, expanded the business so that the Yelloway Pioneer Stages, Inc., now includes about 9000 miles of route. The design of the equipment for the service was developed to meet the severe operating conditions, which demand that the same vehicle run satisfactorily over a sea-level desert and through mountainous country having an average altitude of more than 5000 ft. and, at the same time, that safety and comfort be provided for the passengers. This requires factors of strength and safety that are greatly in excess of those possessed by the ordinary commercial motorcoach.

The present company's ideal of proper operation is to control its inspection and maintenance so that all of its operating properties, including stations and automotive equipment, are kept in practically new condition. The coaches are subjected to a rigid maintenance schedule in combination with a modified unit-maintenance system whereby the major maintenance and repair operations are performed by experts at two main overhaul stations. A comprehensive system of records, based on the reports of drivers, inspectors and shop workers, guides the officials in locating and overcoming chronic weaknesses in the equipment and in the details of operation.

THE entire transcontinental operation of the Yelloway-Pioneer motorcoach system was put into daily operation within a few months. Passengers can leave New York City and travel to Portland, Ore., via Los Angeles, riding the entire distance in vehicles owned and operated under the responsibility of a single company. It resulted from the consolidation of a number of companies which originally had been operating over the greater part of this route, and was benefited by the experience of the California Transit Co. system, which had been operating a long-distance motorcoach service on the Pacific Coast for a number of years and had originally developed a trained operating organization, a proved method of operation, and equipment which lent itself readily to the requirements of transcontinental work. The problem of serving the larger field therefore has been largely one of obtaining a suitable personnel, training the employes and providing enough equipment of the proper character to meet the schedule requirements.

The organization which operates the transcontinental service is patterned after and functions like that of the California Transit Co., being merely a further multiplication of divisions and maintenance plants. The development of this system of operation and maintenance has gone hand in hand with the development of our standard motorcoaches. Both were developed concurrently on the basis of our experience in handling passengers over routes of 500 to 1200 miles. We have therefore been building our own equipment, because no manufacturer is adequately equipped to meet our changing requirements.

The operating methods are not unlike those of a transcontinental railroad. The system is divided into operating divisions, each having its own maintenance facilities and allotted equipment. Reserve motorcoaches are available at strategic points along the line.

Regular stations are provided in all of the main towns along the line. The vehicles make regular stops to take on or discharge passengers at certain designated places in virtually every settlement along the route. The main stations are conducted just as railroad stations are, and the coaches arrive and depart on schedules which arc adhered to very closely. Our first transcontinental schedule from Los Angeles to New York called for arrival there at noon, and the coach drew up to the station just as the whistles were blowing.

Operating Schedule and Speed

Wherever possible the coaches run at an average speed of 32 m.p.h., but the speed varies somewhat on account of conditions in the mountains, local speed regulations and the like. At least two through schedules approximately 12 hr. apart are maintained over the entire transcontinental line and, in places where traffic warrants it, the schedules call for more frequent service. Passengers having through tickets are allowed stop-over privileges at any division point, and stop-overs are allowed when emergency warrants them. Speeding beyond the legal limit is not allowed. In localities having no legal speed limit, our drivers are ordered not to exceed a speed of 40 m.p.h.

Under a bonus system operated on the basis of merit and demerit marks, drivers are rewarded or penalized for adherence or for non-adherence to schedules. Although we regularly penalize drivers who delay departure from stations at their scheduled time, we have never had a case in which a driver was penalized for arriving late. Barring mechanical difficulties, a driver can make his schedule on time; therefore, we penalize drivers whenever they are caught crowding the speed limit to make up time lost between stations.

We keep stand-by equipment within a 2-hr. run of almost every point on our system. On portions of the route where the population is reasonably dense are stationed emergency men or trouble shooters who respond to calls from the drivers for minor repairs en route. We have arrangements with garage men all along the line of the Denver-to-Los Angeles division to perform repair service as needed; but there are surprisingly few road failures, as will be explained in detail under the discussion of our maintenance methods.

We make every effort to provide for the comfort of

[1] President, Yelloway-Pioneer Stages, Inc., Oakland, Cal.

our passengers, in the coaches and at the stations. It is surprising to note the number of passengers who desire to ride the entire distance in the same coach. Since it obviously is impossible to run a continuous schedule without holding the coaches over for regular maintenance work, we try to provide equipment that is as nearly uniform as possible throughout the entire system. It would be disastrous to transfer a passenger from good equipment to inferior equipment. Lack of uniformity of operating methods and equipment had been one of the greatest drawbacks to transcontinental motor-vehicle travel under the systems previously operated.

All baggage is checked. Handbags and suitcases are carried in overhead racks inside the coach if possible. Any pieces too bulky to be placed in the baggage-racks are put into a covered baggage-carrier on the rear of the roof; occasionally, a surplus of small baggage must be placed there also. We want to have baggage available instantly so that a passenger can stop at any point without delaying the schedule. Further, when a passenger gets off, he wants his baggage at once. These requirements for passenger comfort and service influence the design of the equipment.

Climatic Conditions Required Design Modifications

The operating difficulties encountered on portions of our lines impose requirements which must be met in the design of our equipment. For example, San Francisco has a uniformly cool climate and the air is nearly always moist; but, within the first 40 miles after leaving that city, the coaches reach the San Joaquin Valley where very often the temperature is 30 to 40 deg. fahr. higher. From Bakersfield to Los Angeles the coaches run in second or third gear for nearly 2 hr. and, during eight months of the year, this is in the burning heat of the semi-desert.

We have never had a radiator that would not boil during this climb and, until recently, the overheating of the engine caused it to lose a great deal of power on account of pre-expansion of the fuel mixture. This difficulty has been overcome by using a heat-control device which draws air at atmospheric temperature from outside the hood, passes it through the carbureter and transmits it into the engine without passing it over a hot-spot. Regardless of the boiling of the water, we obtain a cool fuel-mixture which burns at full power. When necessary for starting or in cool weather, the heat control allows the air for the carbureter to be drawn through a stove built around the exhaust manifold. This not only has eliminated trouble from overheating but has resulted in an increase in power and in improved engine-performance.

On the route from Los Angeles to Denver, the coaches cross the Mojave desert where the temperature is usually so high that the radiator water boils most of the way. The same cars cross the Continental Divide just beyond Gallup, N. M., at an elevation of 7251 ft. Most of the route across Arizona, New Mexico and Colorado is mountainous and more than a mile above sea-level. Those who have toured through the Rocky Mountains in an automobile are familiar with the loss of power commonly experienced in these altitudes. High engine-compression is necessary to provide full power at such an elevation, and the same engine must also operate under approximately sea-level conditions in burning desert heat without troublesome detonation. The engine that we are using at present seems to meet these conditions more adequately than does any other we have used.

Meeting the Dust Conditions

Most of the roads across the sparsely settled sections of the route are dirt roads and at times are rough. A quantity of dust always is drawn into the carbureter and into the coach body. Engine-blocks, pistons and piston-rings wear out very rapidly on this division, in spite of the use of air-cleaners. We hope to overcome this difficulty by using air-cleaners of a newly developed type, which we are installing as fast as we can obtain them. The screens in this air-cleaner are constantly being washed with oil, as the coach runs, which carries the dirt down and precipitates it into a collecting reservoir. The oily screens take out practically all of the dust and are sufficiently large not to restrict the flow of air, so that the adjustment of the carbureter is not affected.

Our coaches are ventilated through small side-windows at the sides of the main windshield, where the air is as clean as possible, and the windows are covered with very fine brass screening. We endeavor to bring enough air in through these windows to make an out-draft at any other window which may be open, keeping out the dust as much as possible; but, on account of variable winds, the dust cannot always be excluded.

Rough roads make it very essential to use easy-riding springs, and these are supplemented by air springs at the front end. Our standard-coach springs are much longer and wider than the average springs on coaches of the same size; they are used to provide greater comfort and to eliminate breakage. It has been our experience that the cost of maintaining the conventional springs in our service runs higher than the engine cost; hence, for easy riding and for long spring-life, we find it necessary to use these very large springs.

The gasoline problem has affected many elements of the design of our coaches. While we must retain a very high factor of strength in all parts, we try to eliminate all unnecessary weight. Most of our transcontinental coaches weigh nearly 7 tons when ready for the road. A large quantity of fuel is needed to move this weight over the mountains and, since fuel is very expensive there, it is vital that we use an economical engine that always has ample power available.

Most of our coaches have a 4.8-to-1 gear-ratio and can make about 45 m.p.h. at governed speed. To handle a coach with this gear ratio, an engine must have a flat torque-curve which holds up at low engine-speed. With these high-compression engines and a 4.8-to-1 worm-gear, we are able to get a fuel consumption of from 5 to 8 miles per gal. We find that an 80-gal. tank is about the right size to meet our worst conditions. Regarding strength, the frame on our standard coach has a factor of safety of 8, calculated on the force necessary to make a complete spring-closure. Other stressed parts are designed with similar overload capacity.

General Design Considerations

The severe conditions already mentioned indicate that we should certainly fail if our equipment were not designed specially to meet them. Our experience leads us to believe that the extra dependability and greater freedom from road failures of this kind of equipment not only make for more economical service over our less

strenuous routes but are also very valuable factors in building up patronage.

Aside from the specific conditions mentioned, our transcontinental service has added very little to our operating or equipment problems that we had not mastered rather satisfactorily. We had already settled upon a practical standardization of equipment, practice and method. It seems to us that a satisfactory motorcoach for long-distance transportation should be more durable and have a better balance of maintenance requirements than most motorcoaches now possess. Because it is impossible to stop a coach for minute inspection and lubrication while it travels over an 800-mile division at express-train speed, all wearing parts must be of ample dimensions, hardened wherever possible, and as well protected from wear as is practicable.

We would not consider using an engine that is not equipped with a satisfactory oil-filter. We like the freedom from carbon trouble which is a feature of the engines with which most of our fleet is powered. It is highly desirable from the standpoint of economy that routine maintenance-work such as valve grinding, changing of pistons and engine blocks, and all other work which recurs at regular and frequent intervals, should be done without loss of time, and this depends almost entirely upon the design of the engine.

Even the matter of bearing wear has occasioned serious thought on our part. Where it is possible, we are changing all main bearings in the engines to use a new copper-lead alloy and no babbitt metal. This new bearing-metal does not flake off and cause loss of oil pressure, which was a common occurrence in the bronze-backed babbitt-metal bearings; but it cannot be used with any but an extremely hard crankshaft, because this bearing-metal will scratch an ordinary steel shaft. The first set of these bearings that we used was inspected at the end of 140,000 miles of operation and showed less than 0.001 in. of wear. The coach in which they ran was used between Los Angeles and Oakland, over the Ridge Route, where the operating conditions are unusually severe because of the continuous high-speed operation at high temperature.

Easy Operation Prevents Accidents

It is necessary on these long runs that the coach should handle very easily so that the driver will not become so fatigued as to relax his vigilance and have an accident. Not only must steering be easy, but the axle must be designed so as to prevent shimmy, even when using balloon tires over rough roads. The axle and the steering-gear must be properly designed, and must be kept in first-class condition. Four-wheel brakes are as essential as good steering-ability. We find that, with air-operated brakes, our accident record is much better than that for any type of brake which depends on foot pressure for its operation.

Even such apparently minor matters as the maintenance of the gasoline line between the vacuum tank or the fuel-pump and the carbureter are given close attention. A broken gasoline line can stop a coach as completely as can a broken spring. Even the best annealed copper-tubing available is broken by vibration with astonishing frequency unless flexible tubing is used at the points of maximum vibration. Our operating records show that delays caused by broken gasoline lines are almost as frequent as those resulting from any other cause.

We use balloon tires on all of our so-called standard jobs and on all new coaches purchased outside; but, while they are giving us better mileage than high-pressure tires do, there is still room for improvement. It takes a driver nearly an hour to change an inside rear tire when it goes flat, and the passengers always become impatient at such delays. Our balloon tires are furnished under contract; we use 10-ply tires, but feel that we would be much better off with 12-ply casings.

Body features that promote passenger comfort include chairs with reclining backs which latch in three positions. The seats are of double-spring construction and very soft. While ventilation is carefully provided for, we feel that there is room for improvement in the construction of window lifts and methods of preventing the rattling of glass.

Coaches that cross the mountains must be designed so that they will shut out cold air; and they require satisfactory and dependable heaters. We are insulating the floors and walls of our new coaches, because a reasonable amount of passenger comfort must be provided at all times. We even go so far as to install thermos water-fountains in the coaches so that cool drinking-water always is available.

Methods of Maintenance

The best motorcoach in the world would not be successful in this kind of service without painstaking and thorough maintenance that begins on the day it is put into service. Our idea is to keep all wearing parts lubricated and to make a systematic inspection which will enable us to replace all worn parts before they fail. It is our aim to keep the mechanical condition and general appearance of our coaches as nearly the equivalent of new vehicles as is humanly possible. This result is attained through systematic and regular inspection, which we regard as the most important phase of our long-haul transportation. We do not have and do not want any unnecessary reserve equipment; consequently, we must schedule the maintenance work very carefully to prevent forced lay-offs.

We plan to do all overhauling and major-unit repairs at our two main maintenance-plants; at our factory in Oakland, Cal., and at Chicago. We also have what we call "A" maintenance stations at Portland, Ore.; Oakland and Los Angeles, Calif.; Gallup, N. M.; and Denver, Kansas City, St. Louis, Chicago, Pittsburgh and New York. Our "B" maintenance stations are located at points approximately 200 to 250 miles apart throughout the entire system.

Our "A" stations are located at division points and correspond to the roundhouses of a railroad system. The entire coach is given a thorough inspection, cleaning, and lubrication in these stations, which are rapidly being provided with such complete assemblies as transmissions, driveshaft sections, springs and engine heads; and any minor repairs necessary for the proper operation of the vehicle between overhauls are performed there also. When it becomes necessary to take a unit out of a coach, the unit is returned to one of the overhaul stations, where it is repaired and placed in stock for use when required.

We try to keep the engines in the same chassis all the time on account of complications incidental to reregistration which follow the practice of changing engines to other chassis. In this respect the laws in some States are very bad, in that we would be required to

re-register a coach in case of an engine change and pay a full year's tax which, in some cases, is very high. The motor-vehicle laws in these States were enacted with the idea of controlling automobile thefts; probably the law-makers had no conception of the economic aspect from the viewpoint of the motorcoach operator. This is a phase which might well be considered in connection with the uniform motor-vehicle law that is now being promoted.

Replacement Parts and Records

A sufficient quantity of spare-parts stock to care for the ordinary requirements of the coaches on the division is carried at each of the "A" shops. The system of handling the stock makes each of these stations virtually a branch of the main stations at Oakland and Chicago, where purchases are made and full supplies carried. No local purchasing is done at the "A" stations except in case of emergency.

The "B" maintenance stations are concerned chiefly with lubrication of the parts which lose their oil most easily, together with an inspection of the more important parts from the viewpoint of safety. No coach is ever allowed to leave either an "A" or a "B" station before the oil level in the engine has been checked, the transmission and the differential inspected, the radiator filled, the tire pressure tested, the wheel bolts tightened, and the inside and outside of the vehicle cleaned.

A record of all work done on each coach is signed and turned in by the inspector. Uniform time-cards are used throughout the system, on which all labor charged to repairs and maintenance is recorded. This card has been worked out so that we can allocate the work performed to any unit or main sub-assembly in the coach. The stock-rooms charge out all materials against the same job numbers that are carried on the labor card. By means of these two records, the auditor is able to analyze the cost of labor and material used in the maintenance of each coach on separate records, and to consolidate all costs afterward.

Our record of failures, from the reports of the drivers and the trouble shooters, enables us to determine the relative durability and dependability of each unit in a vehicle. We use this absolute record to guide us in strengthening weak points. The monthly sheet which we compile from the shop cards and stock-room charge-outs gives us a cost record, not only of failures, but also of the regular maintenance work on each of these units and sub-assemblies.

Overhauling Stations Equipped Simply

Our main overhauling stations are not elaborately equipped; they have the usual lathes, drill-presses, grinders, power cranes and small tools. Almost the only special tools we have for engine work are boring bars with which we cut all main bearings to the size of the crankshafts at a single operation, and a tandem drill with which we cut both the bearing and the bushing end of connecting-rods simultaneously. We are now supplying our "A" maintenance stations with complete equipment for refacing and grinding valves and reaming valve-seats.

The training of men to handle the maintenance of our motorcoaches at all of these outlying stations has been one of the greatest problems we have faced. We like to train our maintenance superintendents at the main plant, where they can work successively in the chassis, axle, transmission, and engine departments, to make them thoroughly familiar with all the equipment they will have to handle, as well as to familiarize them with records and reports which we require to get the necessary operating and cost records. This has not been possible in all cases, but we have been able to secure enough good men from the operating companies which merged with our present system to enable us to carry on.

Our total number of miles of operation per month is rapidly increasing; the record for September, 1928, shows 1,500,000 miles on approximately 9000 miles of route.

Inspection and maintenance of equipment are the keynote of long-haul transportation. This applies not only to the coaches, but to every piece of operating property and to operating methods as well. Passengers are no more willing to tolerate dirty and inadequate station facilities, or careless and indifferent operating employes, than they are to tolerate broken-down and unclean coaches. Our standards are set by the demands of our patrons. While it is a tremendous task to organize and perfect such an operating system, we expect in time to put the system on a basis that closely approaches our ideal.

THE DISCUSSION

Chairman Martin Schreiber[2]:—Do long-distance-motorcoach passengers prefer to stop at hotels at night or to ride straight through to their destination?

F. C. Murdock[3]:—Our experience is that about 80 per cent of the passengers, from motives of economy, prefer to ride straight through; however, for the convenience of tourists, we sell a ticket which allows 30 days in which to complete the trip.

R. E. Plimpton[4]:—What are the possibilities of successful operation of so-called "sleeper" types of motorcoach?

Mr. Murdock:—Our organization has been working on plans for a sleeper type of motorcoach, but finds that it is possible to accommodate only 12 passengers. It would be impractical to operate on that basis without charging a tariff which would be prohibitive.

E. F. Loomis[5]:—What reasons other than economy induce passengers to ride long distances in a motorcoach?

Mr. Murdock:—Many women prefer the motorcoach to the railroad train, claiming that, especially in summer, the train is hot and stuffy. Other people prefer the motorcoach because it travels through scenic parts of the Country and through city streets, residential and suburban sections, thus affording an opportunity to

[2] General manager in charge of plant, Public Service Coordinated Transport, Newark, N. J.

[3] Manager, Capitol Theatre Bus Terminal, New York City; who, in the absence of the author, presented the paper and answered the questions asked in the discussion.

[4] M.S.A.E.—Associate editor, *Bus Transportation*, Chicago.

[5] Secretary of truck committee, National Automobile Chamber of Commerce, New York City.

see the best of the cities and towns and the scenic beauties of the countryside.

E. S. PARDOE[6]:—What provision do you make against overcrowding the vehicle?

MR. MURDOCK:—Passengers are booked according to the seating chart of the vehicle. We do not sell a specific seat, but we do sell space up to the limit of the seating capacity. Our coaches have no wheelhouse seats, yet they carry 26 passengers. The aisle is 12 in. wide.

POLICY TOWARD LOCAL OPERATORS

MR. PLIMPTON:—What is the company's policy toward existing local operators? In time, will the long-distance services take over the intrastate or local operations on the same highway as a matter of economy and convenience?

MR. MURDOCK:—It is the policy of the company to cooperate with existing local operators wherever possible, and such cooperation has proved to be a convenience to the public as well as a benefit to the operators.

Answering the second question, it would certainly have a bearing on operating costs to combine the local and long-distance service out of division points where garage and service stations are maintained; but I do not believe it would be of any great importance to combine local and long-distance operations at intermediate points along the route where service or garage stations were not established, unless interstate motorcoaches have the same rights as do intrastate motorcoaches.

F. J. DALY[7]:—What means have the long-haul operators for replacements in the event of equipment trouble?

MR. MURDOCK:—Spare equipment is available within a few hours of the trouble along the entire route.

M. C. HORINE[8]:—Some motorcoach lines operating over moderately long distances will pick up through passengers along the route, the driver selling the ticket. Granting that this is an advantage, is it feasible?

MR. MURDOCK:—Our drivers may pick up a passenger if a seat is available and carry him to the next terminal station, where the proper fare is collected; but the driver is not permitted to sell transportation beyond that point. The reason is that the driver does not know what space has already been sold beyond the next station.

MR. HORINE:—If I lived on a highway used by long-distance motorcoaches, would I need to travel to the terminal station of the coach line to board the coach? If so, I would not do it because that is just what is required of a railroad passenger.

MR. MURDOCK:—You could telephone the motorcoach station and the coach would stop for you, provided a seat was available.

MR. LOOMIS:—If a motorcoach passes through several States, must it carry the license plate of each State through which it operates?

MR. MURDOCK:—Yes.

MR. PLIMPTON:—What are your views on interstate regulation of motorcoaches?

MR. MURDOCK:—I believe that interstate regulation of motorcoaches is essential to the proper development of the industry. I do not believe in any drastic measures that would tend to retard the natural growth, but in measures that will protect the invested capital and assure protection to the traveler by permitting the kind of service demanded by the public. I believe further in uniform laws that would afford standardization of equipment for use in all parts of the Country, a reasonable interstate taxation to eliminate waste, and in State laws fitted to the needs of public carriers—not laws formed for private-car operation, to which the motorcoach operator must conform.

H. F. MCGLONE[9]:—Motorcoach lines of two classes operate out of cities such as St. Louis and Chicago, the rates being cheaper on the inferior class. What effect has such competition on your line?

MR. MURDOCK:—Lines operating motorcoaches out of established terminals known to the public have an advantage in loading to greater capacity than do motorcoaches that load at street corners, and the former can command a reasonable price for the transportation; the rate may be a little higher because of the upkeep of such terminals, but the traveling public appreciates the better service rendered. Price-cutting is in most instances resorted to by weak and unorganized lines in an attempt to keep going. It results, however, in impoverished equipment and poor service.

N. D. BALLANTINE[10]:—Is your reserve equipment of vehicles operated simply as reserve equipment, or is it pooled with the equipment in regular service?

MR. MURDOCK:—Our reserve vehicles are pooled with those in regular service, and we aim to keep them in active operation.

MAINTENANCE OF SAFE SPEED

MR. DALY:—Will the long-haul passenger-business be increased by guaranteeing a safe speed? Is it practicable for a driver to endeavor to make up lost time; or is your schedule flexible enough to permit the making up of lost time at a safe and reasonable speed?

MR. MURDOCK:—Even if a driver start out late, he is not permitted to attempt to make up that lost time. We prefer to have the motorcoach arrive late at its division station or at its destination than to allow the drivers to attempt to speed up beyond the limit set by the State through which the vehicle may be passing. Our engines are governed to limit the speed to 45 m.p.h. In California, where the speed limit is 50 m.p.h., a very fast service is maintained between San Francisco and Los Angeles, but even that run could be made at an average speed of 26 m.p.h. The distance of 3540 miles between New York and Los Angeles is covered in 5 days 14 hr., or at approximately 26 m.p.h., which is certainly within the requirements of the State regulations. In every instance in which a company allows its motorcoaches to exceed the State speed-limits, I think it can be proved that the insurance costs are very heavy because there are many accidents. We have found that passengers prefer to travel on a line that has a reputation for safety, rather than to over-speed to reach their destination.

MR. MCGLONE:—In Kansas City, Omaha, St. Louis, and Chicago, where there are motorcoach lines which operate at a lower rate of fare than is charged by the operators of first-class vehicles, I have noticed that passengers will look over the lower-class vehicle and then

---

[6] Jun. S.A.E.—Superintendent, bus operations, Capital Traction Co., City of Washington.

[7] Senior inspector of traffic, Board of Public Utility Commissioners, State of New Jersey, Newark, N. J.

[8] M.S.A.E.—Manager, sales promotion department, International Motor Co., New York City.

[9] General Motors Corp., New York City.

[10] A.S.A.E.—Consulting engineer, New York City.

travel in the better vehicle at a higher fare. Seemingly, they are influenced to do this by considerations of safety. As traffic increases, will there be a field for the low-priced service in inferior vehicles which cater to the poorer class of passengers?

MR. MURDOCK:—When State or Federal regulatory legislation becomes effective, the day of the wild-catter and price-cutter will be over. When that time comes, no doubt many of the existing lines will merge; the tendency is in that direction. We believe that the railroads will enter the motorcoach business at that time also. The railroads are operated by conservatives who want assurance that their investments in the motorcoach transportation-service are safe. Those who are in the long-haul motorcoach business today are striving for position and are trying to complete their plans. Operation of a line between New York and Montreal will begin soon, even though the cost of fighting snow north of Albany, N. Y., during the coming winter will mean an expense of $30,000 to $40,000. In the snow belt, between Watertown and Ogdensburg, N. Y., the motorcoach line operators keep the highways open, which is also of great benefit to passenger-car owners.

E. J. GRAHAM[11]:—Is it not a fact that the majority of the so-called "gyp" vehicles are owned individually and that many of them are operating with no insurance coverage whatever? Either the owners do not have money enough to buy the insurance or the insurance companies will not grant insurance on their low-class vehicles.

MR. MURDOCK:—I do not know, but I will say that many individual owners have combined in operating fairly extensive services. A future possibility exists for establishment of hourly service between New York City and Los Angeles. That service is possible because, after all, the long-haul-motorcoach operator carries passengers to intermediate points across State lines and, after the passage of regulatory legislation, it will be possible for the local operators and the long-haul operators to cooperate by transferring within State boundaries.

W. A. MCCUTCHEON[12]:—Do you use equipment in the mountainous sections of your route that has a different gear-ratio from that used in the level country?

MR. MURDOCK:—We have equipment that is built particularly for use in mountainous sections. The engine has a 5-in. bore and a 7-in. stroke and develops 148 hp.

C. M. LARSON[13]:—Have you plans for what you consider to be ideal motorcoach service-station facilities?

MR. MURDOCK:—Plans are being prepared for the establishment of service stations between New York and Los Angeles which will be installed, however, only where inadequate stations exist or where there are none.

PROBABILITY OF BERTHS FOR NIGHT TRAVEL

F. C. HORNER[14]:—Is there real demand for motorcoaches equipped with berths for night travel?

MR. MURDOCK:—Usually, when such service is advertised, it refers to a motorcoach equipped with reclining chairs provided with several adjustments. For this reason, many people have the mistaken idea that these vehicles are equipped with berths and all that goes with the equipment of a railroad sleeping-car.

MR. HORNER:—I think we are rapidly reaching the point at which there will be a real demand for motorcoaches equipped with sleeping facilities. Such a service is now being operated between Liverpool and London. The vehicle runs regularly three times a week. It is divided into three compartments, each of which contains four berths, specially sprung to minimize road shocks. Each compartment is curtained and is provided with electric light, a window equipped with a blind, and a rack for the traveler's clothes. A steward is on board to look after the passengers and to awaken them when nearing their destination; in a manner, his service is similar to that of a Pullman porter. This is an indication of what is coming in this Country, if I read the signs aright.

The tremendous development of long-distance-motorcoach transportation during this last year has been perfectly astounding to me, especially when we consider that this has been accomplished with what might justly be called a more or less haphazard operating service. If the motorcoach operators have been getting such a tremendous number of passengers with that kind of service, how many passengers will they obtain when they can give a real service? When we have passed the phase of developing equipment, proper terminals, scientific routing and scheduling, and stable rates of fare, long-distance-motorcoach travel unquestionably will be a very important part of the transportation structure of this Country. I am of the opinion that the company represented by Mr. Travis could inaugurate a sleeping-car service next summer and obtain a sufficient number of passengers to make it pay.

MR. MURDOCK:—There is no doubt that in the very near future sleeping facilities will be part of the equipment used in motorcoach operation, but I do not believe that a transcontinental service can be inaugurated so soon as next summer.

The operation in England to which Mr. Horner refers, carrying 12 passengers, is feasible insofar as building the equipment is concerned, but whether such service could be priced to the traveling public at a rate sufficiently attractive to justify its use remains to be seen. A survey of the situation at present indicates clearly that the majority of passengers use motorcoaches because it is more economical to do so. If we accept that as a fact and measure our future possibilities along that line, it would mean that the fare on motorcoaches would need to be kept within 60 per cent of the total railroad coach and Pullman fare; which would mean an increase of 30 per cent on the present tariffs for the additional service rendered. But, even on that basis, a possibility exists for successful operation of "sleepers."

MR. PLIMPTON:—One company of which I know has recently developed a 12-passenger motorcoach equipped with sleeping arrangements. I rode in it recently. It has a lounge compartment in the rear in which a phonograph, radio set and other conveniences are provided. A shower bath, lavatory and toilet are also provided. I understand that it is to be used as a directors' car.

MR. MURDOCK:—Our company is experimenting with a coach in which the berths run crosswise rather than longitudinally. In that design we can accommodate 12 passengers, two in each compartment; but, so far, we have been unable to design for more than 12 passengers.

[11] A.S.A.E.—Superintendent of transportation, Public Service Co. of Colorado, Denver.

[12] Jun. S.A.E.—Superintendent, automobile department, West Penn Power Co., Connellsville, Pa.

[13] M.S.A.E.—Supervising engineer, Sinclair Refining Co., New York City.

[14] M.S.A.E.—Assistant to vice-president, General Motors Corp., New York City.

Dispelling the Mystery of Gear-Tooth Breakage, Wear and Noise

By A. B. Cox[1]

PRODUCTION MEETING PAPER

Illustrated with DRAWINGS

IT is the primary purpose to deal in this paper with problems of gear-tooth breakage, wear and noise, that frequently have been insolvable without complete redesign. Such causes of gear trouble as poor material, poor treatment of material, and errors in machining and assembly will be considered only as they affect the application of remedial measures for the less obvious troubles.

The three essential requirements of gearing are:

(1) Strength to transmit the desired load under any and all reasonably possible conditions
(2) Ability to resist wear sufficiently to have an economic life
(3) Reasonable quietness for the type of mechanism to which the gears are applied

These essentials must be obtained in economic competition with drives of other more or less desirable types, such as belt, chain, electric and direct connection. A large proportion of modern gearing is designed wastefully, compared with what might be done with the same amount of material at a lower cost.

The problem of designing a set of gears to obtain the maximum load-carrying capacity—that is, strength—for the money invested is not simple. It is important for the designer to know how and when the gears are required to be strong. Are the gears to be subjected to high starting-loads? Then they must have high static strength. Are they to be run at high speed? Then the inaccuracies of manufacture subject the teeth to high impact stresses which, if not allowed for, will break out the teeth, and it is important for the designer to know the amount of error that is to be tolerated in the gearset. Are the gears to be subjected to high shock-loads, as in street-cars, automobiles, electric locomotives, or steel-mill gears? Then a type of design should be chosen that is suitable to withstand shock, for gears of various designs differ greatly in shock-load strength. Must the gears have high strength when new and before they have had a chance to wear in? Supposedly good modern gear designs differ in their "new" strength in a ratio of as much as 4 to 1. Are the gears special; or are they only one set of many somewhat similar designs, all to be cut by the same standardized cutters? On the answer to this question will depend the choice of standardizing high-strength gear teeth.

The usual ways of obtaining great tooth-strength are to make the teeth as short as possible; to make the pressure angle as great as possible, for a tooth that is wide at the base; and to use good material and as coarse a pitch and as wide a face as are consistent with requirements of space, weight and cost. On account of the inflexibility of such teeth, the highest accuracy of tooth contour and spacing that are economically attainable must be striven for to minimize impact stresses. These methods have been pushed to their utmost practicable limits in such tooth systems as the Maag. In such designs there never is continuousy more than one pair of teeth in contact to carry the load.

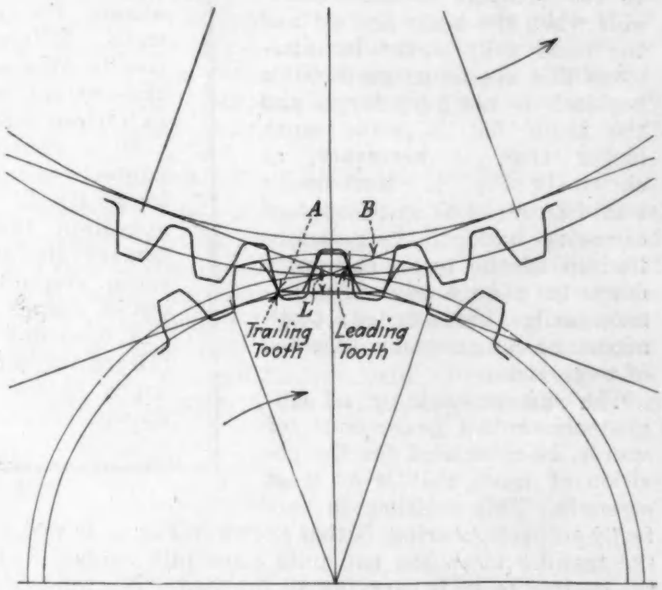


FIG. 1—TOOTH CONTACT IN STUB-TOOTH GEARS

The Specifications of These Gears Are: Driver, 25 Teeth; Driven, 47 Teeth; Pitch, 7; Pressure Angle, 20 Deg.; Contact Distance *AB*, 1.36 Pitches. *L* Is the Beam Length in the Position Shown

In such single-tooth-contact designs, care must be used to provide sufficient tooth-contact overlap so that, even when the gear and pinion-shaft bearings are worn and the shafts are deflected under load, both to the greatest permissible extent, and when all the manufacturing tolerances combine to reduce the duration of tooth contact, still the leading tooth in the zone of contact shall not leave contact before the next following, or trailing, tooth makes contact. This means that the average calculated number of teeth in contact should be not less than about 1.4. This number is equal to the length of the line of action included between the outside diameters of the meshing gears, *A-B*, in Fig. 1, divided by the normal, or base-circle pitch. In extreme cases a number slightly smaller than 1.4 can be used, but safe

[1] Consulting engineer, Wilkinsburg, Pa.

tooth-overlap is jeopardized by so doing, and in such cases the engineering must be done very carefully.

The single-tooth-contact gearset is not the strongest possible design, but the strength of the individual teeth can be made the greatest possible for this type of design by using as large a pressure angle and as large a fillet at the root of the tooth as possible without interfering with the teeth of the meshing gear. The size of the root fillet makes more difference in the strength of the teeth than is commonly realized. Fig. 2, taken from a paper[3] presented by S. Timoshenko and R. V. Baud before the American Gear Manufacturers' Association, shows the distribution of stress at the root of the tooth, with a small fillet at *A* and a large fillet at *B*. The best tooth fillet is not a circular arc.

Since pointed gear teeth are practically equal-strength parabolas, as indicated in Figs. 4 and 5, the "flat" at the end of the tooth makes no difference in the strength. Ordinarily this flat can be made approximately equal to the greatest backlash allowable when the gears are old and the teeth fully worn. In many cases this maximum permissible backlash is not very large, and the tooth flat is made much larger than is necessary, as shown in Fig. 1. Most gears would be renewed on account of excessive backlash long before the tip of the tooth had worn down to a knife-edge. An unnecessarily broad-ended tooth means an unnecessary sacrifice of tooth strength.

The safe strength of all single-tooth-contact gears must, of course, be calculated for the position of mesh that is of least strength. This position, in perfectly accurate gearing, is that shown in Fig. 1, in which the trailing tooth has not quite come into contact and the leading tooth is carrying all the load. The total dependable strength of such gears is therefore the strength of this leading tooth alone, with the total gear load applied at the distance *L* from the root of the tooth. When the trailing tooth comes into contact and shares the load with the leading tooth, the total strength of the gears is the combined strength of the two pairs of teeth. But, since this second tooth is not always in contact, its strength cannot be added to that of the leading tooth for either steady-load strength or shock-load strength. Also, on account of the great stiffness of these short teeth, there is very little deflection under load; hence, errors in tooth contour and in tooth spacing cannot be compensated for by the deflection of the teeth; and, unless the gears are extremely accurate, such gears require the use of a very high velocity-correction in strength calculations.

Since the deflection of a cantilever varies as the cube of the length of the lever, a very slight increase in the depth of the tooth makes a relatively great change in its flexibility. If inaccuracies exist in the gears sufficient to keep the trailing tooth out of mesh until the leading tooth is leaving contact at the end of the contact zone, the position of most unfavorable strength will be that of total load concentrated at the tip of a single tooth, and the strength of the gears is much reduced. On account of the inflexibility of single-contact teeth, a comparatively small error is sufficient to hold the trailing tooth out of mesh and cause all the load to be carried by a single tooth through the entire length of the contact zone.

In this paper the author attempts to show why underloaded gears of conservative design sometimes break, wear out, or are unreasonably noisy.

The remedy for these faults is stated to be the use of the integral-contact-gear system, in which the load is always divided among the same number of teeth. References are made to results obtained by the use of this system, which is patented, in various classes of service.

It is claimed that integral-contact gears are stronger, longer-lived, and quieter in operation than gears of customary design, and that the tooth contour does not wear out of shape.

A tendency of gear designers toward the use of teeth of extra depth instead of stub teeth is shown.

Fig. 3 shows a set of standard full-depth teeth exactly similar to the standard stub-teeth of Fig. 1 except for the tooth depth and size of root fillet. These gears are very little stronger than those of Fig. 1 if both sets are assumed to be accurately made and mounted, and they are very much weaker if sufficient inaccuracy exists in the gears to cause the load to be carried on only one pair of teeth at the end of the contact zone.

Fig. 4 shows a set of gears designed so that they will always have two pairs of teeth in contact, no matter what the relative positions of the gears may be during rotation. Assuming that the gear teeth are accurately formed and spaced so that the total-load pressure transmitted by the gears is shared by the two pairs of contacting teeth, it is easy to see that the weakest position of these gears is that shown in Fig. 4. In this position, the leading pinion-tooth is just on the point of dropping its load. On account of the relatively greater deflection of the leading tooth, it carries less than half the transmitted-load pressure, although there are factors which tend to make up for this condition. The tooth is loaded as a cantilever with the force applied at the greatest possible distance from the root. The trailing tooth is carrying the greater load-pressure, but, since the force is acting on it at a point much closer to the root than is the case on the leading tooth, this tooth is less likely to break than is the leading tooth. At first sight the pointed tooth looks weak, but the inscribed equal-strength parabola shows that it is as strong at the tip as at the root; that is, the teeth are substantially constant-strength cantilevers. The minimum total steady-load strength of these gears is therefore the sum of the strengths of the leading and the trailing teeth, and is greater than that of either of the designs shown in Figs. 1 and 3.

Supposing that, in these two-tooth-contact gears, because of errors in tooth contour and tooth spacing, the trailing pair of teeth does not make contact in time to help in carrying the load as intended by the designer, three things tend to relieve the condition:

(1) Under any practically permissible error of mod-

[3] See *Automotive Industries*, July 22, 1926, p. 138.

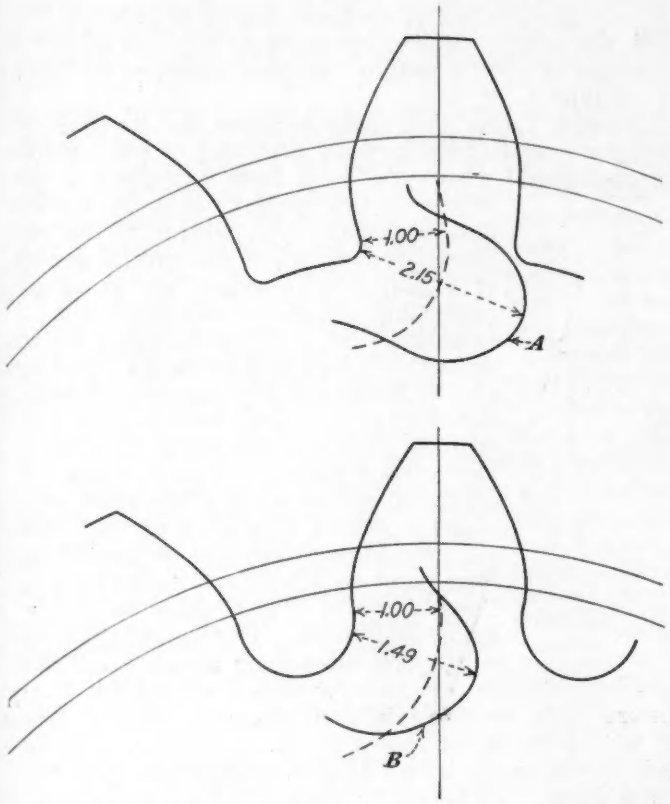


FIG. 2—INFLUENCE OF ROOT FILLET ON TOOTH STRENGTH
A, Stress Distribution with Small Fillet. *B*, Stress Distribution with Large Fillet

ern commercial gearing, the leading tooth will deflect sufficiently to overcome the effect of the error and cause the trailing tooth to come into contact long before a breaking stress in the leading tooth is reached.

(2) If the load on the leading tooth is further increased up to the breaking point, the trailing tooth will take up an increasingly greater proportion of the total gear-load as the leading tooth deflects, on account of its much smaller deflection; and, by the time the stress in the leading tooth reaches the breaking point, the trailing tooth will have taken up so large a share of the total load that its metal also will be close to the breaking-point stress. This favorable condition of approximate stress-equalization always exists when the load occurs in peaks, or as shock loads; it exists for steady loads only when the gears are new or comparatively unworn.

(3) Because wear of gear-tooth contours is due primarily to tooth pressure, if there are errors of either tooth contour or tooth spacing which tend to make any pair of teeth carry more than their share of the load, these teeth will wear down more rapidly than the more lightly loaded pairs of teeth. The effect of this wear is easily seen to be toward the equal division of the total-load pressure among the pairs of teeth in contact.

From every viewpoint, therefore, whether the gears are new or worn, it is safe to assume equal division of load between the pairs of contacting teeth as a basis for calculating the total minimum steady-load static strength of these gears. Such gears, having always two pairs of teeth in contact, have been given the name of integral-contact gears.

EXAMPLES OF INTEGRAL CONTACT

Because of the greater elasticity of the longer teeth of integral-contact gears, a smaller velocity-correction can be used than for short-tooth gears. Gears described by H. Hofer[8] carried a load of 1680 lb. per in. of face width at a speed of 1500 r.p.m. Calculating the static stress in these teeth on the basis of exactly equal division of load between the two pairs of contacting teeth, a value of 125,000 lb. per sq. in. is obtained. At last

[8] See *Zeitschrift des Vereines Deutscher Ingineure*, October, 1926, p. 1460

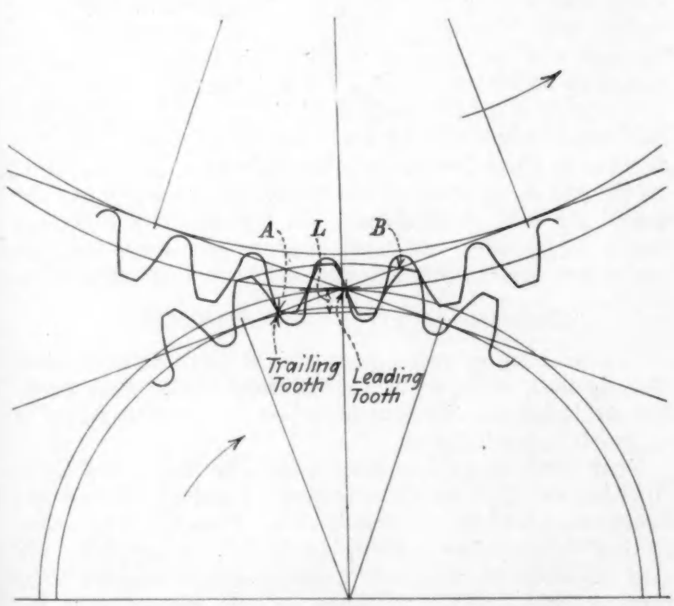


FIG. 3—CONTACT BETWEEN GEARS WITH TEETH OF STANDARD FORM
These Gears Have the Same Specifications as Those in Fig. 1, Except that the Contact Distance *AB* Is 1.68 Pitches

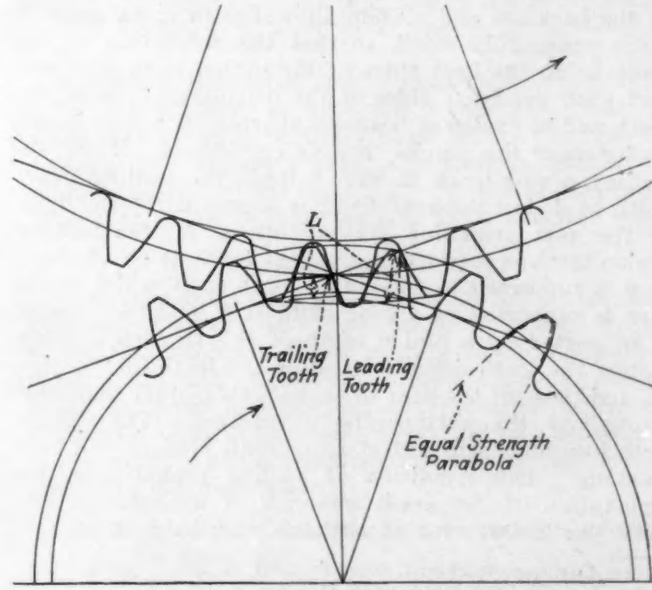


FIG. 4—INTEGRAL-CONTACT GEARS
These Gears Have the Same Specifications as Those in Figs. 1 and 3, Except that the Contact Distance Is 2 Pitches

report the gears had run 10 hr. per day for 3½ months and were then running even better than at first.

Calculations for main-drive gears for 2000-hp. 90-m.p.h. electric locomotives, in which the space available for gearing is more than ordinarily limited and both starting loads and impact loads are very great, have shown the integral-contact design to be approximately twice as strong for steady loads and four times as strong for shock loads as the best competitive design of single-contact gears. These calculations were made on the basis of an assumed maximum error in tooth spacing and tooth contour of 0.003 in. in both sets of gears. Since gear teeth seldom break under steady load but nearly always under shock load, the high shock-load strength of integral-contact gears makes it possible to design such gears with a very low factor of safety for steady load. This increases the total load-carrying capacity of integral-contact gears still further beyond that of other gears.

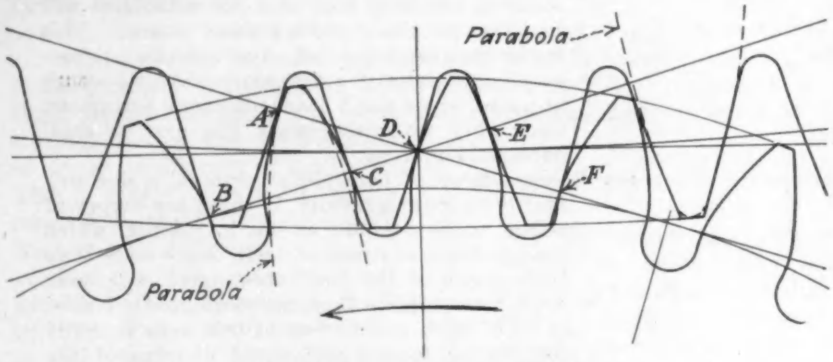


FIG. 5—TRIPLE-CONTACT GEARS

The Specifications of These Gears Are: Driver, 36 Teeth; Driven, 144 Teeth; Pitch, 3; Pressure Angle, 17 Deg.; Contact Distance, 3 Pitches

Calculating the strength of the teeth as cantilevers, gears having always more than two pairs of teeth in contact do not show such great static strength as those having only two pairs in contact. Fig. 5 shows a set of gears which have always three pairs of teeth in contact. If the backlash and oil-film allowance in these gears is made reasonably small, so that the deflections of the teeth bring the back sides of the pinion teeth into contact with the front sides of the mating-gear teeth, the teeth will be loaded as beams supported at both ends and loaded near the middle, not as cantilevers. Thus the leading pinion-tooth in Fig. 5 loads the leading gear-tooth at *A*, but the gear tooth is supported by the flank of the next preceding pinion-tooth at *B*; the leading pinion-tooth is supported on a gear tooth at *C*, which in turn is supported by the pinion tooth at *D*, which in its turn is supported by a gear tooth at *E*, and that finally is supported by a pinion tooth at *F*. In such a tooth system the tooth deflection causes the teeth of the pinion and those of the gear to support each other mutually throughout the entire zone of contact. Three-pitch teeth like these will deflect more than 1/64 in. without breaking. This condition of loading probably is the explanation of the great strength of multiple-contact teeth, particularly for shock loads. Probably, also, the greater the number of load-carrying tooth-pairs is, the less the velocity correction needs to be. An extreme example of such a design has been produced by John T. Wilkin[4].

Another factor that tends to make the strength of integral-contact gears greater than that of other gears is mechanical resonance, as I have explained in an article[5] on this subject. It is well known that all gears have natural periods of vibration and that, if the natural period of a gear is approached too closely by something periodic in the conditions of operation, the teeth will be subjected to excessively high pressures, and pitting and breakage will be dangerously likely. Whether or not the trouble from mechanical resonance is sufficient to give immediately noticeable results, every set of non-integral-contact gears must necessarily operate in a more or less resonant condition which can be located as some point on a resonance curve such as those shown in Fig. 6, from an article[6] by R. Soderberg. This means that all such gears have their strength reduced by some unknown resonance factor to a value below their theoretically possible minimum strength. This is true of helical gears, as shown by A. H. Candee[7], and of spiral-bevel gears as well as of spur gears and straight-bevel gears.

Also, it is a matter of actual observation that integral-contact-gear teeth tend to wear so as automatically to correct the tooth form, and that other gears tend to wear out of shape, as shown exaggerated in Fig. 7. For peak loads and shock loads that occur so seldom as not to affect the tooth contour appreciably by wear, the leading tooth of integral-contact gearing deflects and allows the trailing tooth to carry much more than its proportionate share of the load. Since the point of application of the load on the trailing tooth is so near the root, this tooth has the strength of a stub-tooth, and the total shock-load strength of the gears is approximately twice that of their steady-load strength. Single-contact gears have no reserve strength to resist shock loads. When it is known in advance that a set of integral-contact gears is to carry a large steady load, it is possible to adjust the tooth form during the cutting or other forming process to allow for the greater deflection of the leading tooth, and so to equalize the tooth stress even when the gears are new. Adjustment in the opposite direction tends to equalize the tooth-surface pressure, but the gears are stronger when new without this correction.

GROOVING AT PITCH LINE ELIMINATED

The problem of wear as it affects tooth strength has already been dealt with; the solution of the wear problem as it affects the durability or life of the gears is of much more interest.

Gear-tooth wear has been found to be primarily a function of tooth-surface pressure; not of sliding velocity, as might be supposed. This does not mean that sliding velocity has nothing to do with wear, but only that its effect is relatively unimportant, compared with that of tooth-surface pressure. C. W. Ham and J. W. Huckert state, in their report on An Investigation of the Efficiency and Durability of Spur Gears[8]:

"Apparently, for any pair of gears, there is a critical

[4] See *American Machinist*, Nov. 24, 1927, p. 809.
[5] See *American Machinist*, May 24, 1928, p. 848.
[6] See *The Electrical Journal*, January, 1924, p. 41.
[7] See *American Machinist*, March 19, 1925, p. 457.
[8] See University of Illinois Engineering Experiment Station Bulletin No. 149, July 20, 1925, p. 56.

surface-pressure, governed by the properties of the materials, above which the life of the gears is short and below which the gears will run indefinitely without appreciable wear."

From this it is easy to see why some non-integral-contact-gear teeth wear out of shape and become noisy. During the portion of the period of contact of a given pair of teeth when no other pair of teeth is in contact, that is, when the tooth curves of the meshing gear-teeth are in contact near their pitch circles, the tooth pressure is equal to the total pressure transmitted by the gears. If this pressure is near to that critical amount or exceeds it, that part of the tooth contours will wear rapidly and be grooved, as shown in Fig. 7. When the teeth are in contact near the base circles or near the tips, two pairs are in contact so that the pressure between the pairs is approximately half the total load transmitted by the gears, and is much below the critical amount. These parts of the tooth contour should wear much more slowly than the parts at the pitch line; and they do wear slowly, except as the groove at the pitch line tends to extend itself by the excessive impact-pressures set up by the action of the groove itself. Papers by E. Buckingham[9] and R. S. Drummond[10] give further evidence of this condition.

It is easy also to see now why integral-contact gears, which have always the same number of pairs of teeth in contact and sharing the load, do not wear their contours irregularly, and why they wear very much less, for the same load transmitted, than other gears. Conversely, for the same length of life, integral-contact gears are able to carry much greater loads than other gears, or they can be made with narrower face or of cheaper materials or given cheaper heat-treatment.

This greatly increased life of integral-contact gears is a matter also of observation of gears in actual commercial use[11]. The uniform wear of the gear-tooth contour is important in services in which it is necessary to renew pinions from time to time, as those who have tried renewing non-integral-contact pinions know.

The excessive tooth-stresses set up by the mechanical resonance of non-integral-contact gears affect the wear of the teeth, of course, as well as the strength. This is the only plausible explanation of the otherwise inexplicable pitting of some underloaded gear-teeth. By combining gear-tooth-strength formulas with wear formulas, it can be shown that, to have somewhere nearly the same factor of safety against wear as against breakage, much finer pitches than are now customary should be used for a given transmitted load.

Sometimes gears that are quiet when new become noisy as they wear in service, and other gears that are noisy when new "wear in" and become quiet as they wear in service. Still other gears show no appreciable change in the noise made from the time they are first operated until they are worn out. The ideal is to have gears that are quiet, even when quite new, and remain quiet during the entire period of their useful life. This ideal is difficult to attain, more difficult in nearly every case than to make gears that are only passably quiet and let them wear in, if they will, to greater quietness.

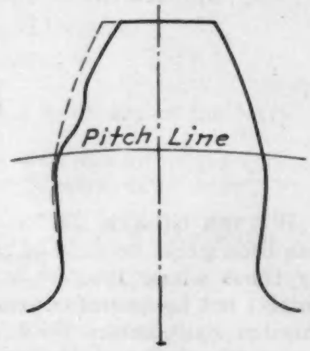


FIG. 7—TYPICAL WEAR OF A STANDARD SPUR-GEAR TOOTH, EXAGGERATED

To obtain exceptional quietness in new gears, exceptional accuracy in the manufacture and assembling of the gears must be maintained. However, it is a matter of common knowledge that, in some instances of ordinary gear-design, no degree of accuracy alone is sufficient to prevent noise. The remedy for this condition, as both I. Short[12] and I[13] state, is to use integral-contact gears. It is an observed fact that, even when new, integral-contact gears are quieter than other gears of the same degree of accuracy. It is also an observed fact that integral-contact gears can be depended upon to "wear in" and become quieter with continued use, whereas other gears are likely to become noisier with wear. This is true of high-speed gears and low-speed gears, of spur gears, helical gears and bevel gears. Of course, if the tooth form is very inaccurate, the gears never will become quiet; as an extreme example, wheels with triangular notches for tooth spaces could not be meshed together and be expected to wear down finally to an involute form.

Sometimes transmission-case resonance is blamed for noise, but it must be apparent to everyone that the gears themselves must make noise before the case can resonate it. Apparent gear noise can be lessened by suitable design of the case, but it is better to prevent noise than to try to suppress it after it has been made.

CONCLUSIONS

From the foregoing partial outline of accumulated evidence of theory and experiment, it is safe to conclude that integral-contact gearing is the solution of most of the baffling problems of gear-tooth fatigue and breakage, wear and pitting, and vibration and noise. Compared with other modern gearing of the best designs, integral-contact gearing has shown itself to have the following qualities:

(1) Much greater strength, both for steady load and for shock load

(2) Much longer life; or smaller dimensions or cheaper materials or cheaper manufacturing processes for the same strength and length of life

[9] See *American Machinist*, May 20, 1926, p. 777.

[10] See THE JOURNAL, January, 1927, p. 132.

[11] See *Zeitschrift des Vereines Deutscher Ingineure*, October, 1926, p. 1460.

[12] See *Power*, May 1, 1928, p. 761.

[13] See *American Machinist*, May 24, 1928, p. 848.

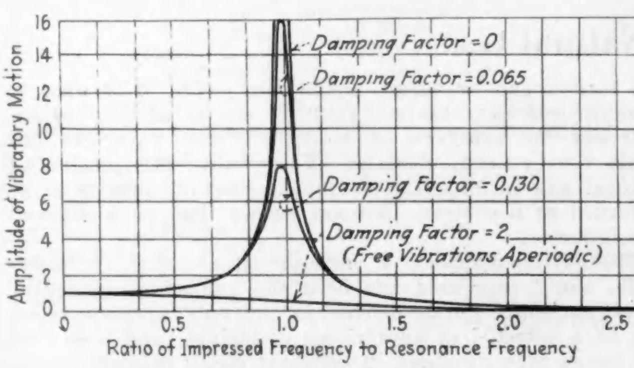


FIG. 6—EXAMPLES OF RESONANCE CURVES

(3) A greater degree of both initial quietness and enduring quietness

This type of gearing should be particularly suitable for automobile transmissions and timing gears, and for replacing spiral-bevel drive-gears with straight-bevel gears. On account of the characteristic action of bevel gears, smaller numbers of teeth can be used for integral contact than is possible in parallel-shaft gears. The minimum number for spur-gear pinions is about 16, and for bevel pinions is about 13.

The improvement secured by the use of integral-contact gears is not slight, and it is not limited to one design feature or to features of minor importance, but extends to all three of the major essentials of gearing. Virtually the only objection of any importance that can be made to the use of these gears is that their design requires greater engineering skill than usually is employed in the design of customary gears. However, considering their advantages, it will be strange indeed if they are not adopted for every sort of drive that offers any economic possibility for their application.

Power-Transmission Engineering

(*Concluded from p.* 57)

WALTER GILMER, JR.[10]:—My interest in this session has been great because of the fact that it was proposed by those whose interest is in production efficiency directly; not by manufacturers of belting or power-transmission equipment. While not now connected with the power-transmission industry, an experience of more than 20 years in that line leads me to join with enthusiasm in any attempt to impress upon production men in all industries the vital importance of power-transmission engineering on production and cost.

Mr. Nichols gives information, formulas, charts and recommendations that are fundamental in this work. I wish to emphasize one of his statements by saying that the most important recommendation to be made is that the management wake up and take an interest in power-transmission engineering.

Every engineer has some idea of how small a part of the latent power in fuel is converted into useful work; but few seem to realize that, after generating the power, the typical plant is losing in transmission lines at least 20 per cent of the power generated because the management does not recognize the importance of power-transmission engineering. At least 5 per cent of the power consumed in every plant can be saved by following the advice given by Mr. Nichols. A properly functioning power-transmission-engineering department will show a tremendous saving in power, belting, equipment, tools, time, and maintenance costs. Further, I can say from my own observation that there is not a department operating principally with power-driven machinery in any plant that I can recall where the installation of such engineering cannot produce an increase of 10 per cent in production.

[10] M.S.A.E.—Detroit.

[11] Belting supervisor, Oakland Motor Car Co., Pontiac, Mich.

CHARTS TO MEASURE FATIGUE

FRED SCHWARTZ[11]:—I have been using at the Oakland plant a meter to find out whether we were using too light or too heavy motors for various jobs, or whether the machine had the size of pulley that was most desirable and would accommodate the right size of belt. We are using the meter also as a time-saving detector to check up on men in the shop. We have a system of plugging into a motor and making a chart that tells the amount of time that the operator wastes and the effect of fatigue upon the operator as the day wears on. We are able to tell the way the operator slows up toward noon and evening.

We also are keeping a very accurate record to determine the belting costs. During the last year the belting costs have been reduced about 50 per cent in our plant; and the number of repairs made on belting has been reduced about 75 per cent as a result of thoroughly watching the machinery and checking the materials used for power transmission. I find also that the charts we get from these meters are very valuable when machinery is being changed from one operation to another. When we are to utilize for the manufacture of a new part a machine that has been used for another part, we can determine from these charts the power and the time required, the production to be had from the machine, and other information that may be wanted. I believe that it is one of the best checks that can be had.

Chemicals from Natural Gas

AS a chemical raw material, natural gas has many actual and potential uses. The dry gas consists chiefly of methane, while wet gas contains also considerable quantities of higher saturated hydrocarbons, such as butane and pentane. These latter now are usually extracted by compression or absorption, giving natural gasoline for blending ordinary gasoline to make it more volatile. Some of them are chlorinated to amyl chlorides, from which are derived the various amylenes, amyl alcohols, and acetates useful in the lacquer, perfume, and flavoring industries.

Even methane is chlorinated to some extent, giving methyl chloride, chloroform, and carbon tetrachloride. But the latter two are made more cheaply in another way, and the former can be made only in low yield. It is used in domestic refrigeration and could be converted into methanol; but the synthesis of methanol from water-gas has made that process obsolete. Essentially, chlorination of natural gas is an outlet for cheap chlorine and must be regarded as a chlorine industry rather than as a natural-gas industry.

The partial oxidation of methane to methanol, formaldehyde, and formic acid has been the subject of numerous investigations. Formaldehyde is the only product which has been detected in appreciable quantities, and even that has never been produced in sufficient yields to justify commercial exploitation.—Bulletin of Arthur D. Little, Inc.

Reports of Divisions to Standards Committee

Standards Committee Meeting Jan. 15

In this issue of THE JOURNAL are printed reports that have been prepared for submission to the Standards Committee and to the Society by 13 Divisions of the Standards Committee since the Summer Meeting last June.

All of the reports are submitted at this time for approval after having been considered carefully by the respective Divisions and given as wide publicity as possible by publication in this or previous issues of THE JOURNAL. The reports as now presented are believed to be in acceptable form, and any proposals should be only in the nature of important and carefully considered constructive changes.

Under the Standards Committee procedure, these reports may be approved as presented, amended within limitations, or referred back to the respective Divisions for sufficient reason. The action taken on them by the Standards Committee will be passed upon by the Council and the general business session of the Society, with the purpose of approving them for submission to letter ballot of the members of the Society as the final step in their adoption. The letter ballot will be counted 30 days following the Standards Committee Meeting, and the reports on which the vote is affirmative will be published in the S. A. E. HANDBOOK.

Rejection or major changes in any of the reports will require that they be sent back to the Divisions that prepared them and that they cannot be passed upon again before the Summer Meeting of the Society next June. In voting on the reports at the Standards Committee Meeting, the Regulations require that only members of the Standards Committee do so.

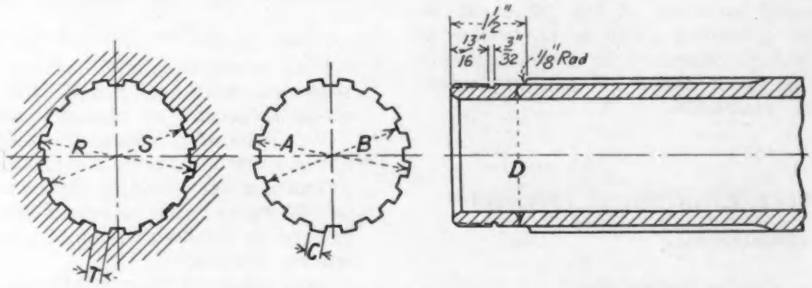
Aeronautic Division

PERSONNEL

Edward P. Warner, *Chairman*	Assistant Secretary of the Navy
Arthur Nutt, *Vice-Chairman*	Curtiss Aeroplane & Motor Co.
Archibald Black	Black & Bigelow, Inc.
V. E. Clark	Buffalo
J. W. Crowley, Jr.	National Advisory Committee for Aeronautics
J. F. Hardecker	Naval Aircraft Factory
Lieut. C. B. Harper	Bureau of Aeronautics
E. T. Jones	Wright Aeronautical Corp.
I. M. Laddon	Consolidated Aircraft Corp.
C. J. McCarthy	Chance Vought Corp.
Major Leslie MacDill	United States Air Corps
W. B. Mayo	Ford Motor Co.
G. J. Mead	Pratt & Whitney Aircraft Co.
L. D. Seymour	National Air Transport, Inc.
R. H. Upson	Aeromarine-Klemm Corp.
Edward Wallace	Glenn L. Martin Co.
Karl H. White	Bellanca Aircraft Corp.
L. M. Woolson	Packard Motor Car Co.
T. P. Wright	Curtiss Aeroplane & Motor Co.
P. G. Zimmerman	Paul G. Zimmerman Metal Aircraft

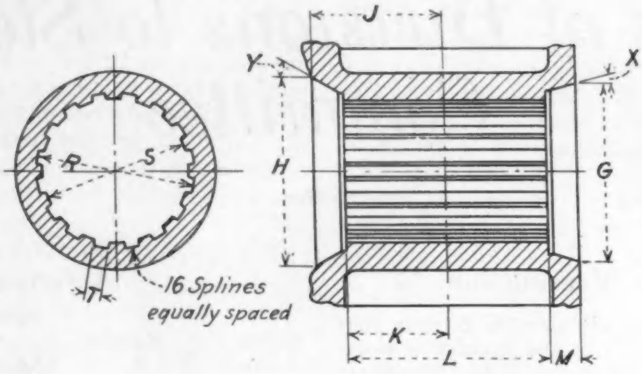
PROPELLER-HUBS AND SHAFT-ENDS

Owing to a few discrepancies between the present S.A.E. Standard for Propeller-Hubs and Shaft-Ends and the manufacturing practice, it has been necessary for the Division to make a few minor revisions in dimensions and



	Shaft-Ends					Hub		
	A	*B*	*C*	Thread	*D*	*R*	*S*	*T*
Shaft No. 10	2.000+0.000 −0.002	1.781 max.	0.194±0.0008	1¾-12 U. S. F.	1.750+0.000 −0.002	2.008+0.005 −0.002	1.787+0.005 −0.002	0.1960±0.001
Shaft No. 20	2.375+0.000 −0.002	2.156 max.	0.231±0.0008	2⅛-12 U. S. F.	2.125+0.000 −0.002	2.383+0.005 −0.002	2.164+0.005 −0.002	0.2330±0.001
Shaft No. 30	2.625+0.000 −0.002	2.411 max.	0.257±0.0008	2⅜-12 U. S. F.	2.375+0.000 −0.002	2.633+0.005 −0.002	2.414+0.005 −0.001	0.2590±0.001
Shaft No. 40	3.125+0.000 −0.002	2.875 max.	0.304±0.0008	2¹³⁄₁₆-12 U. S.F.	2.850+0.000 −0.002	3.133+0.005 −0.002	2.881+0.005 −0.002	0.3060±0.001

Number of Splines = 16



	Front End	Rear End								For Rear Cone	For Front Cone
	H	*G*	*J*	*K*	*L*	*M*	*R*	*S*	*T*	*X*	*Y*
Hub No. 10	2.750+0.005 −0.000	2.500+0.005 −0.000	2 7/32	1 5/8	3 1/4	5/8	2.008+0.005 −0.002	1.787+0.005 −0.002	0.1960±0.001	15°	30°
Hub No. 20	3.125+0.005 −0.000	2.875+0.005 −0.000	2 5/8	2	4	5/8	2.383+0.005 −0.002	2.164+0.005 −0.002	0.2330±0.001	15°	30°
Hub No. 30	3.187+0.005 −0.000	3.187+0.005 −0.000	2 25/32	2 3/16	4 3/8	5/8	2.633+0.005 −0.002	2.414+0.005 −0.002	0.2590±0.001	15°	30°
Hub No. 40	3.875+0.005 −0.000	3.625+0.005 −0.000	2 5/8	2	4	5/8	3.133+0.005 −0.002	2.881+0.005 −0.002	0.3060±0.001	15°	30°

Number of Splines=16

tolerances. In addition to these revisions, some changes have been made in dimension *D*, reducing this diameter so that splined shafts can be hobbed when desired.

The present standards contain no specifications for splined shafts for engines of low horsepower, and in consequence the Division has approved splined shaft No. 10, together with a hub for it.

The Division recommends approval of the tables of dimensions on this and the preceding page as a revision of and an addition to the S.A.E. Standard on Propeller-Hubs and Shaft-Ends shown on pp. 2 and 3 of the Supplement to the 1928 edition of the HANDBOOK.

Agricultural Power-Equipment Division

PERSONNEL

Prof. A. C. Young, *Chairman*	Purdue University
O. B. Zimmerman, *Vice-Chairman*	International Harvester Co.
A. H. Gilbert	Rock Island Plow Co.
R. O. Hendrickson	J. I. Case Threshing Machine Co.
Pliny E. Holt	Stockton, Calif.
H. E. McCray	Waterloo Gasoline Engine Co.
John Mainland	Advance-Rumely Co.
R. L. Miller	Huber Mfg. Co.
A. C. Rasmussen	Insley Mfg. Co.
Prof. O. W. Sjogren	University of Nebraska
O. W. Young	Hyatt Roller Bearing Co.

TRACTOR POWER-TAKE-OFF SPEED

The Division recommends that the present S.A.E. Recommended Practice on Tractor Power-Take-Off Speed, on p. 66 of the 1928 edition of the HANDBOOK, be amended to include details relating to the spline fitting and the sizes of power-take-off shafts. This proposed addition is at present a standard of the Society of Agricultural Engineers, having been adopted by that organization and agreed to by the tractor manufacturers. The Division also recommends that, when amended, the specification become an S.A.E. Standard.

TRACTOR POWER-TAKE-OFF SPEED

(*Proposed S.A.E. Standard*)

The power-take-off shaft on the tractor shall be provided with an S.A.E. 6B spline fitting. The straight length at the root of the spline shall be 3 in. Retaining means for securing the fitting shall not project more than 1 in. from the end of the spline.

The normal speed of the power-take-off shaft shall be 536 r.p.m., plus or minus 20, the direction of rotation to be clockwise when facing in the direction the tractor travels.

Two sizes of power-take-off shaft shall be used, as follows:

(1) The 1 1/8-in. splined shaft on tractors with engines developing up to 20 b-hp.

(2) The 1 3/8-in. splined shaft on tractors with engines developing up to 40 b-hp.

These ratings are based on the use of material having a minimum torsional yield-point of 65,000 lb. per sq. in.

Axle and Wheels Division

PERSONNEL

L. R. Buckendale, *Chairman*	Timken-Detroit Axle Co.
O. A. Parker, *Vice-Chairman*	Parker Wheel Co.
B. B. Bachman	Autocar Co.
G. W. Carlson	Eaton Axle & Spring Co.

C. C. Carlton	Motor Wheel Corp.
G. W. Harper	Columbia Axle Co.
J. H. Hunt	Motor Wheel Corp.
E. R. Jacobi	Kelsey-Hayes Wheel Corp.
W. F. Rockwell	Pittsburgh Equitable Meter Co.
F. L. Sage	Graham Bros.
George Walther	Dayton Steel Foundry Co.

Front-Axle Hubs

A summary of replies on the use of the S.A.E. Specifications on Front-Axle Hubs, pp. 289 to 301, in the 1928 edition of the S.A.E. Handbook, indicates that of 18 passenger-car companies only one uses these specifications. Of 26 truck companies replying, 2 use the specifications, 14 do not, and 10 leave the matter of axle and hub dimensions to axle manufacturers.

The axle and wheel manufacturers, judging from the comments submitted, follow various designs as required by other features of the chassis for which the axle and wheels are made. The type of bearings used also affects the design to a large extent. It is therefore evident that the S.A.E. Specifications are little used.

The question of cancellation of these specifications was submitted to the Division by letter-ballot, and of the 10 members of the Division replying, 6 voted in favor of cancellation and 4 in favor of revision. The Standards Committee is therefore requested to decide whether, on the basis of this vote, these specifications should be cancelled.

Electric Vehicle Division

PERSONNEL

Charles R. Skinner, Jr., *Chairman*	New York Edison Co.
C. J. Blakeslee	Walker Vehicle Co.
Oscar E. H. Froelich	Ward Motor Vehicle Co.
C. H. Meeker	The Lansden Co., Inc.
H. M. Pierce	New York City

Charging Plug and Receptacle

To bring the S.A.E. Standard on Charging Plugs and Receptacles, p. 155 of the 1928 edition of the Handbook, into accord with present manufacturing practice, it is necessary that the capacity of the smaller plug, which is now rated at 50 amp., should be changed to show a capacity rating of 100 amp. It is understood that this rating is now in use for this plug and is approved by the Underwriters Laboratories.

This minor revision was submitted to the Electric Vehicle Division by letter-ballot and approved, and is therefore submitted to the Standards Committee for its approval.

Electrical Equipment Division

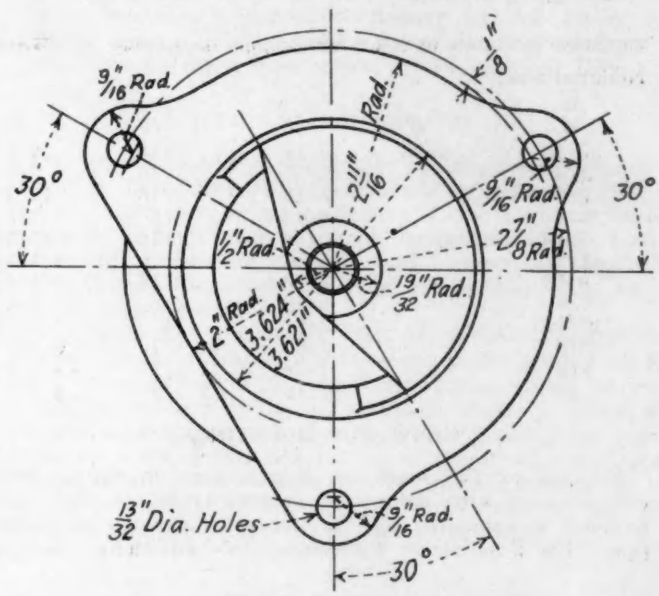
PERSONNEL

A. R. Lewellen, *Chairman*	Chevrolet Motor Co.
D. M. Pierson, *Vice-Chairman*	Chrysler Corp.
Azel Ames	Kerite Insulated Wire & Cable Co.
A. K. Brumbaugh	White Motor Co.
D. S. Cole	Leece-Neville Co.
W. S. Haggott	Packard Electric Co.
T. L. Lee	North East Electric Co.
B. M. Leece	Leece-Neville Co.
L. E. Lighton	Electric Storage Battery Co.
F. H. Prescott	Anderson, Ind.
B. M. Smarr	General Motors Corp.
T. E. Wagar	Studebaker Corp. of America
J. G. Wood	Olds Motor Works

Starting-Motor Mountings

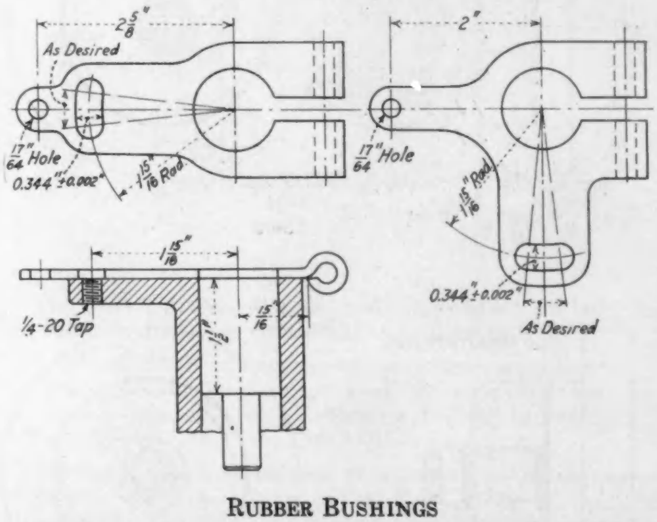
The Division recommends cancellation of the present No. 3 Standard Starting-Motor Mountings, as shown on p. 107 of the 1928 edition of the Handbook, as this type is becoming obsolete and is not in use at present.

It further recommends that the present No. 2 Starting-Motor Flange shown on the same page be replaced by the flange illustrated herewith, which is identical with the present No. 2 flange except for the cut-off side. As this cut-off type is used in most installations, it is felt that this design should be the standard rather than the present No. 2, which is in use in very few installations.



Timer Distributors

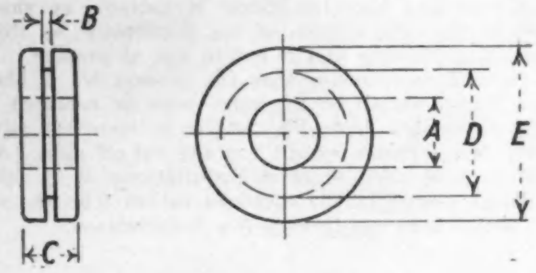
Acting on the report of the Subdivision, the Division recommends the adoption of the specification illustrated for timer-distributor hold-down arm and screw as an addition to the passenger-car-type standard timer-distributor mountings on p. 100 of the 1928 edition of the Handbook.



Rubber Bushings

Because the S.A.E. Standard includes a large number of rubber-bushing sizes that are not used and are not obtainable, a Subdivision appointed to revise the specifications submitted the following report to the Division with a recommendation that it be adopted as a revision of the present Standard on Rubber Bushings shown on p. 158 of the 1928 edition of the Handbook. The Division there-

fore recommends that this new table of sizes be approved by the Standards Committee.



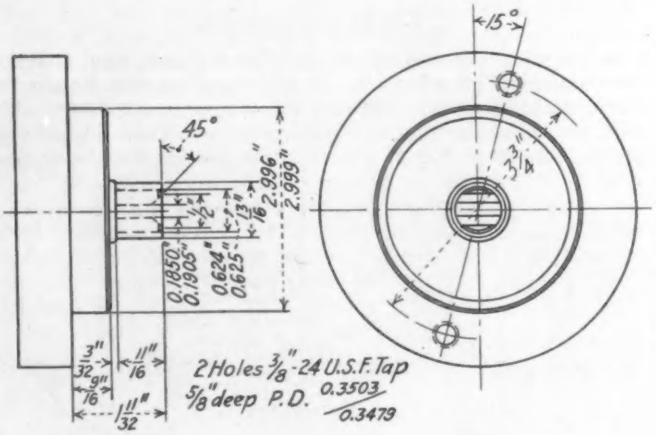
PROPOSED REVISION OF S.A.E. STANDARDS ON RUBBER BUSHINGS

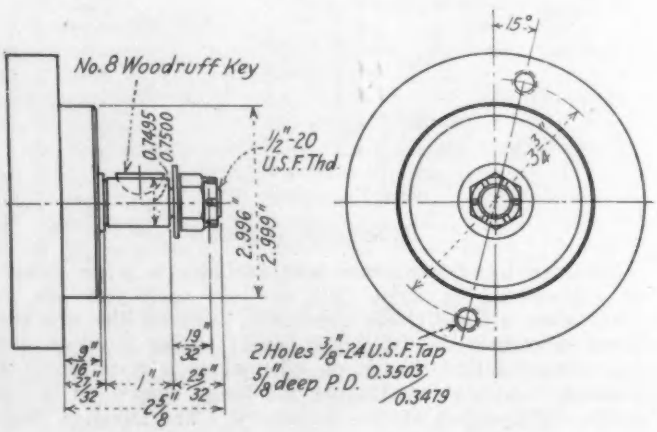
Nominal Size, In. A	B	C	D	E
3/16	1/16	3/16	5/16	7/16
1/4		3/16	7/16	5/8
5/16		5/16	9/16	13/16
3/8		5/16	5/8	7/8
7/16		5/16	11/16	15/16
1/2		5/16	13/16	1 1/16
9/16		5/16	13/16	1 1/16
5/8		5/16	7/8	1 1/8
11/16		3/8	1	1 5/16
3/4		3/8	1 1/16	1 3/8
7/8		7/16	1 1/4	1 5/8
1		7/16	1 3/8	1 3/4

GENERATOR MOUNTINGS

Because of the need for a generator mounting that can be used with flanges of several types, or that will make it possible to bolt the generator directly to chain cases, the Subdivision formulated two additional designs for generator mountings for use with adapter-type flanges. These will enable the use of two-bolt flanges and other types where necessary, while still providing that generators shall be interchangeable.

To accomplish this, the Division recommends the adoption of the two generator-ends illustrated, as additions to the present S.A.E. Standard Generator Mountings.





Lighting Division

PERSONNEL

C. A. Michel, *Chairman*	Guide Motor Lamp Mfg. Co.
R. N. Falge, *Vice-Chairman*	General Motors Corp.
Clyde C. Bohner	Tung-Sol Lamp Works
H. S. Broadbent	Westinghouse Lamp Co.
P. J. Kent	Chrysler Corp.
R. E. Carlson	Edison Lamp Works
A. W. Devine	Registry of Motor-Vehicles, Commonwealth of Massachusetts
A. R. Lewellen	Chevrolet Motor Co.
H. C. Doane	Buick Motor Co.
H. H. Magdsick	National Lamp Works, General Electric Co.
Walter Spear	Cincinnati Victor Co.
W. F. Thoms	Indiana Lamp Corp.
T. E. Wagar	Studebaker Corp. of America

TAIL-LAMPS

The Division recommends that the present tail-lamp specification on pp. 84 and 85, of the 1928 edition of the HANDBOOK, be cancelled and the following specification be approved as a revision, as the present specifications are unsuitable. It is understood that the Subdivision on Rear and Signal Lamps will study this subject further and make additions to this specification as they become necessary.

SPECIFICATIONS GOVERNING ACCEPTABILITY OF TAIL-LAMPS FOR MOTOR-VEHICLES

General.—These specifications are drawn up to apply only to the illumination from electric lamps on opaque registration number-plates for use on motor-vehicles and motorcycles.

Definition.—Tail-Lamp—A lighting unit used to indicate the rear of a vehicle by means of a red light and to illuminate the registration number-plate.

Samples for Tests.—A sample tail-lamp, representative of the type as regularly manufactured and marketed, shall be submitted to the laboratory for tests. Such sample shall include license-plate holder and all necessary equipment for normal operation except batteries.

Incandescent Lamp.—The tail-lamp shall be tested with the lamp for which it is designed and shall be operated at rated candlepower during tests.

Requirements.—Tail-lamps shall emit a red light which, on a line perpendicular to the center of the lamp face, shall be not less than 0.05 candlepower.

The plane of the license plate shall be not more than 15 deg. to the plane of the lamp face.

Tail-lamps shall have a colorless window sufficiently large to permit light to cover the entire surface of the registration number-plate which, for the purpose of this specification, shall be represented for motor-vehicles by a plain surface 16 in. long by 6½ in. wide, and for motorcycles, 10 in. long by 5 in. wide.

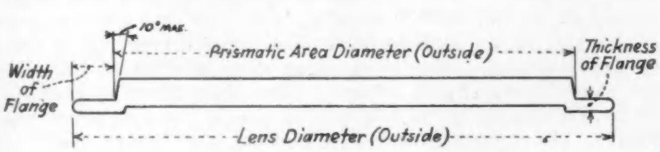
The cut-off illumination shall be not less than 1½ in. from the plate, measured perpendicularly to the plane of the plate at the edge farthest from the lamp.

The light source shall be located not less than $2\frac{1}{4}$ in. from the plane of the front face of the license-plate holder, and not less than $1\frac{1}{2}$ in., nor more than $3\frac{1}{2}$ in., from and above a plane passing through the centers of the bolt slots measured perpendicular to the license plate.

Lamp Lenses

After a survey of the industry to determine the various sizes of head-lamp lenses required, a Subdivision of the Lighting Division presented a report at the last Division meeting involving a series of lens sizes which can be regarded, for the guidance of manufacturers and users, as standard stock sizes.

This matter has been given a great deal of consideration and has been the subject of much discussion at Division meetings. It is felt that the table of sizes presented below is a suitable revision of existing specifications, and the Division therefore recommends that the following be approved as the S.A.E. Standard:



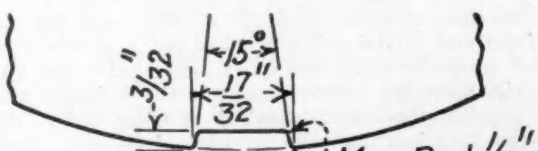
HEADLAMP-LENS AND PRISMATIC-AREA DIAMETERS

Outside Diameter		Diameter of Prismatic Area	
Wide Flange (Approx. ½″)	Narrow Flange (Approx. ¼″)	Maximum	Minimum
8.00	7.50	6.980	6.955
8.25	7.75	7.230	7.205
8.50	8.00	7.480	7.455
8.75	8.25	7.730	7.705
9.00	8.50	7.980	9.955
9.25	8.75	8.230	8.205
9.50	9.00	8.480	8.455
9.75	9.25	8.730	8.705
10.00	9.50	8.980	8.955
10.25	9.75	9.230	9.205
10.50	10.00	9.480	9.455
10.75	10.25	9.730	9.705
11.00	**10.50**	**9.980**	**9.955**
11.25	**10.75**	**10.230**	**10.205**
11.50	**11.00**	**10.480**	**10.455**
11.75	**11.25**	**10.730**	**10.705**
12.00	**11.50**	**10.980**	**10.955**
12.25	**11.75**	**11.230**	**11.205**
12.50	**12.00**	**11.480**	**11.455**
12.75	**12.25**	**11.730**	**11.705**
13.00	**12.50**	**11.980**	**11.955**

The thickness of the lens flange for all sizes of head-lamp lenses shown in the light-face type shall be 5/32 of an inch, plus 1/64, minus 0, at the edge of the prismatic area and shall be not less than ⅛ of an inch at the edge of a lens. For sizes shown in bold-face type the thickness of the flange shall be 3/16 of an inch, plus 1/64, minus 0 and shall be not less than ⅛ of an inch at the edge of a lens.

The rear surface of the lens flange shall be plane.

This standard applies only to motor-vehicle electric head-lamps.



Locating Notch.—A lens-locating notch as illustrated shall be located at the bottom of all lenses except those having no prismatic structure.

The center of the locating notch shall not be more than 1/64 of an inch to either side of the vertical center line of the lens.

Signal Lamps

As the specifications for signal lamps on p. 85 of the 1928 edition of the Handbook are unsatisfactory, and the Subdivision on Rear and Signal Lamps is preparing new specifications, the Division feels it advisable to cancel the present specifications until such time as the revised standard is ready.

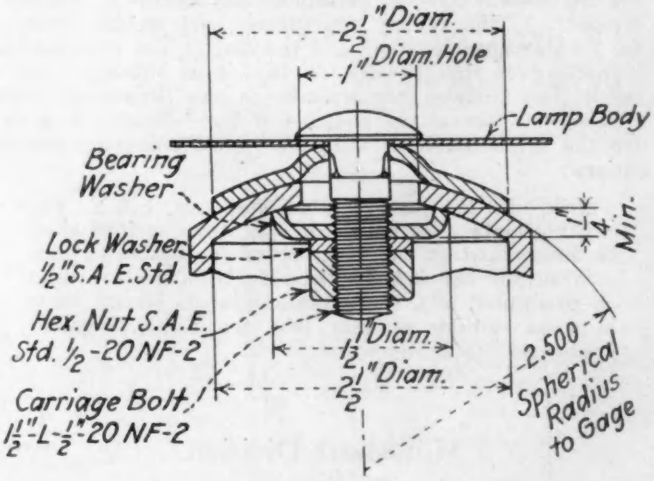
The Division therefore requests approval by the Standards Committee of the cancellation of these specifications and the inclusion of the following note in the Handbook, under the heading of Signal Lamps:

> *Note:* The Recommended Practice on Signal Lamps, published on p. 85 of the 1928 edition of the Handbook, has been found unsatisfactory and has therefore been cancelled, pending a revision now under consideration by a Subdivision of the Lighting Division.

Head-Lamp Mountings

The question of the suitability of the present S.A.E. Standard Head-Lamp Mountings has been under consideration for some time by a Subdivision of the Lighting Division and, while it may be found desirable to make some changes in or additions to the present design when the final report is submitted, this recommendation deals only with clarifying the present design.

The Division recommends that the revised illustration herewith of the universal mounting for passenger-car headlamps be approved. This revised drawing shows an inverted cup-washer of ¼ in. minimum depth in place of the flat-bearing washer shown in the illustration published on p. 74 of the 1928 edition of the Handbook. The $2\frac{1}{2}$-in. spherical radius shown on the revised illustration is revised to read "2.500 spherical radius to gage," so that an accurate and spherical surface shall be provided.



The Division also recommends approval of the addition of the following note underneath the illustration:

> *Note.*—It is recommended that head-lamp-bracket mountings be so designed that the adjusting nut is readily operable with wrenches ordinarily included in tool-kits.

Owing to the obsolescence of all types of mounting except the Universal Type outlined on p. 73 of the 1928 Handbook, the Division recommends the paragraph on this page relating to the Fender Type, Hollow-Prop Type and Fork Type of mounting be cancelled, and that the paragraph on the Universal Type be amended to read:

> All head-lamps shall be mounted so that their centers are not less than 32 in. nor more than 42 in. from the ground, the preferred height being 36 in.

It is recommended that Universal adjustable mountings as shown on p. 74 be used.

Means shall be provided for aiming the beam straight ahead with the upper cut-off horizontal and to permit vertical adjustment over limits of 3 deg. above and below the horizontal.

Lubricants Division

PERSONNEL

E. W. Upham, *Chairman*	Chrysler Corp.
H. C. Mougey, *Vice-Chairman*	General Motors Corp.
Sydney Bevin	Tide Water Oil Co.
O. E. Eckert	Mid-Continent Petroleum Corp.
J. B. Fisher	Waukesha Motor Co.
J. C. Geniesse	Atlantic Refining Co.
W. H. Graves	Packard Motor Car Co.
W. S. James	Studebaker Corp. of America
C. M. Larson	Sinclair Refining Co.
Dr. K. G. MacKenzie	The Texas Co.
H. J. Saladin	Standard Oil Co. of Indiana
F. D. Shields	Transcontinental Oil Co.
C. W. Simpson	White Motor Co.
Dr. H. G. Smith	Gulf Refining Co.
J. B. Terry	Standard Oil Co. of California
R. E. Wilson	Standard Oil Co. of Indiana
C. Dominick	Marland Refining Co.

S.A.E. Viscosity Numbers

The Division presented at the June 1928 meeting of the Standards Committee a report recommending the addition of a note to the present crankcase-lubricating-oil viscosity-number specifications, on p. 470 of the Handbook, covering the classification of prediluted oils by S.A.E. Viscosity Numbers. This report was turned back to the Division for further consideration, and the matter was discussed at a meeting of the Division on Dec. 3 in Chicago. As a result, the Division recommends to the Standards Committee for approval the addition of the following note under the crankcase-lubricating-oil viscosity-number specifications:

> *Note.*—In the case of prediluted oils, S.A.E. Viscosity Numbers by which the oils are classified shall be determined by the viscosity of the undiluted oils.
>
> Wherever the S.A.E. Viscosity Numbers are used on prediluted oils, the container labels should show in some suitable manner that the S.A.E. Number applies to the undiluted oil.

Motorboat Division

PERSONNEL

Leonard Ochtman, Jr., *Chairman*	Elco Works, Electric Boat Co.
C. A. Carlson	Remington Oil Engine, Inc.
N. E. Donnelly	Dawn Boat Corp.
H. E. Frömm	Chrysler Sales Corp.
S. Clyde Kyle	American Car & Foundry Co.
C. D. Salisbury	Winton Engine Co.
H. R. Sutphen	Submarine Boat Corp.
Jos. Van Blerck	Van Blerck Motors, Inc.

Marine Propeller-Hubs and Shaft-Ends

The situation in the motorboat field with respect to propeller-hubs and shaft-ends, and propeller-shaft couplings has been confused for some time. A number of years ago standards were worked out for these parts but, after more study by the Motorboat Division, they were withdrawn a few years later as not meeting the requirements of the industry. The couplings previously standardized apparently had not come into use at all. The propeller-mounting specifications of that time did not fully represent existing practice.

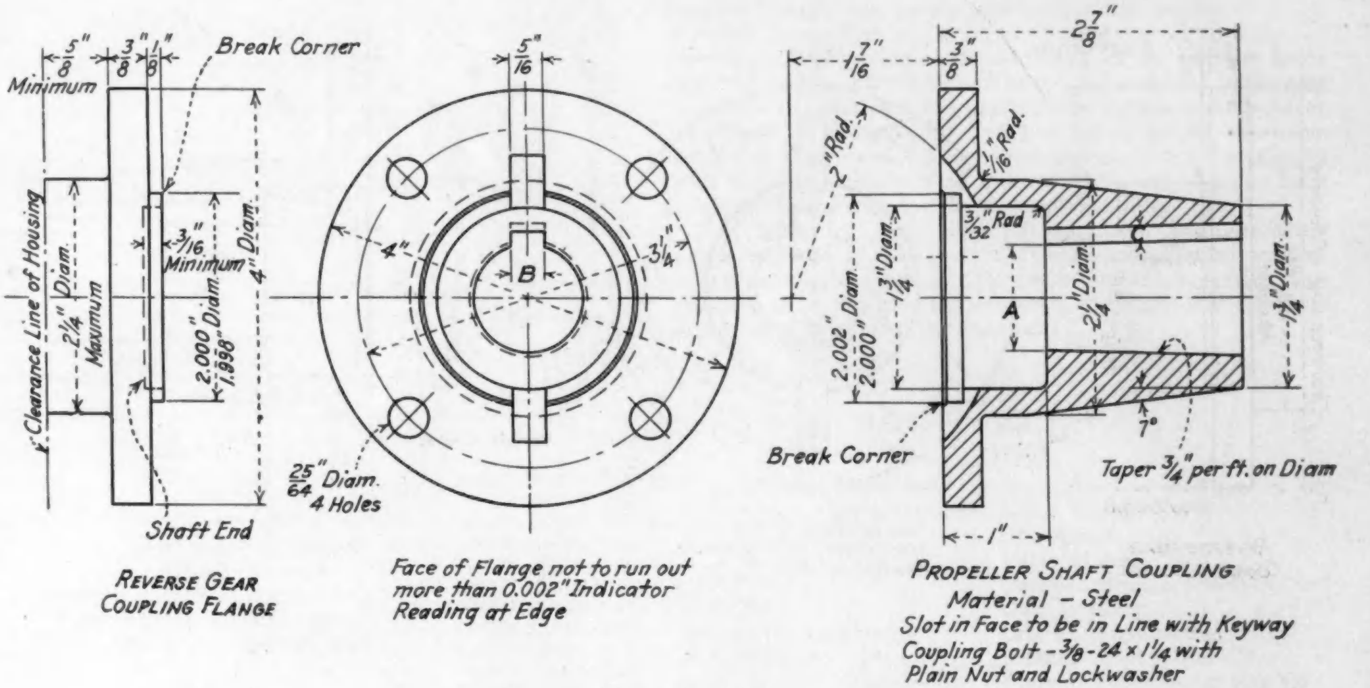
In working out the new specifications, the first point of attack was the propeller-hubs, with particular reference to the bore. It was found that the practice in this respect in sizes up to 3 in. was very uniform throughout the industry, such variations as were found between different companies proving to be very slight. The proposed S.A.E. Standard for Propeller-Hub Bores, as presented at this time, is therefore representative of present practice in this respect.

The situation with respect to the present practice in couplings made this part of the work much more difficult. Hardly any two manufacturers of engines use the same flange diameters in couplings they supply, and even where the diameters agree the number and size of bolts are likely to vary. The method of attaching propeller-shaft couplings to the shafts usually falls into two classes, one a straight fitting and the other the taper fitting. It is recognized that mounting a coupling with a straight bore on the end of a shaft and securing it endwise there by pinning or by set-screws is very widely in use in the motorboat industry. It is not, however a method that lends itself to standardization, for the reasons that a snug fit of the coupling on the shaft is essential and commercial-shafting limits are such that this cannot be accomplished with standard bores in the couplings. The result is that the couplings must be individually fitted and the method becomes a hand-fitting one which is rapidly becoming obsolete in the other industries.

The preferred method of attaching the coupling to the shaft is to draw it on to a taper by means of a nut. This has been used for years to a lesser extent than the straight fitting, provides the safest type of construction from the standpoint of retaining the shaft in place, and makes it possible to remove the coupling readily when desired. In addition, it lends itself admirably to standardization, as it is easy to machine the parts so that they will fit properly. An increasing practice with respect to taper fittings on propeller-shaft couplings is to use the same taper on both ends of the shaft, thus making it possible to turn the shaft end for end when one portion has become worn, thus doubling its useful life. The standard taper for the propeller bores is ¾ in. per ft. This requires, therefore, that this taper be used in the coupling end as well. While this does not agree with former practice for tapered-coupling use on propeller-shafts, the advantage of having a reversible propeller-shaft is so great that it is felt that this should be adopted.

It may be pointed out that using this construction requires the threaded ends of the shafts to be alike at both ends. Further, since the coupling nut should be locked preferably with a cotter-pin, a fine thread rather than the usual coarse thread is desired on the ends. This also does not agree with the usual practice on the propeller end, where a coarse thread is largely used. Experience in the use of a fine thread at this point has disclosed no objection, and the results in use have been satisfactory.

Taking into consideration all of the foregoing factors, the Motorboat Division has worked out a series of recommended propeller-shaft couplings and shaft-ends which it feels will meet the requirements of the industry and will make possible the standardization of these units. It must be borne in mind that the Division does not expect this practice to be adopted over night. Such changes must come gradually and must be made in such a way that they do not interfere with servicing existing equipment. It is, however, desired very strongly that, if these recommendations meet the approval of the industry, their adoption



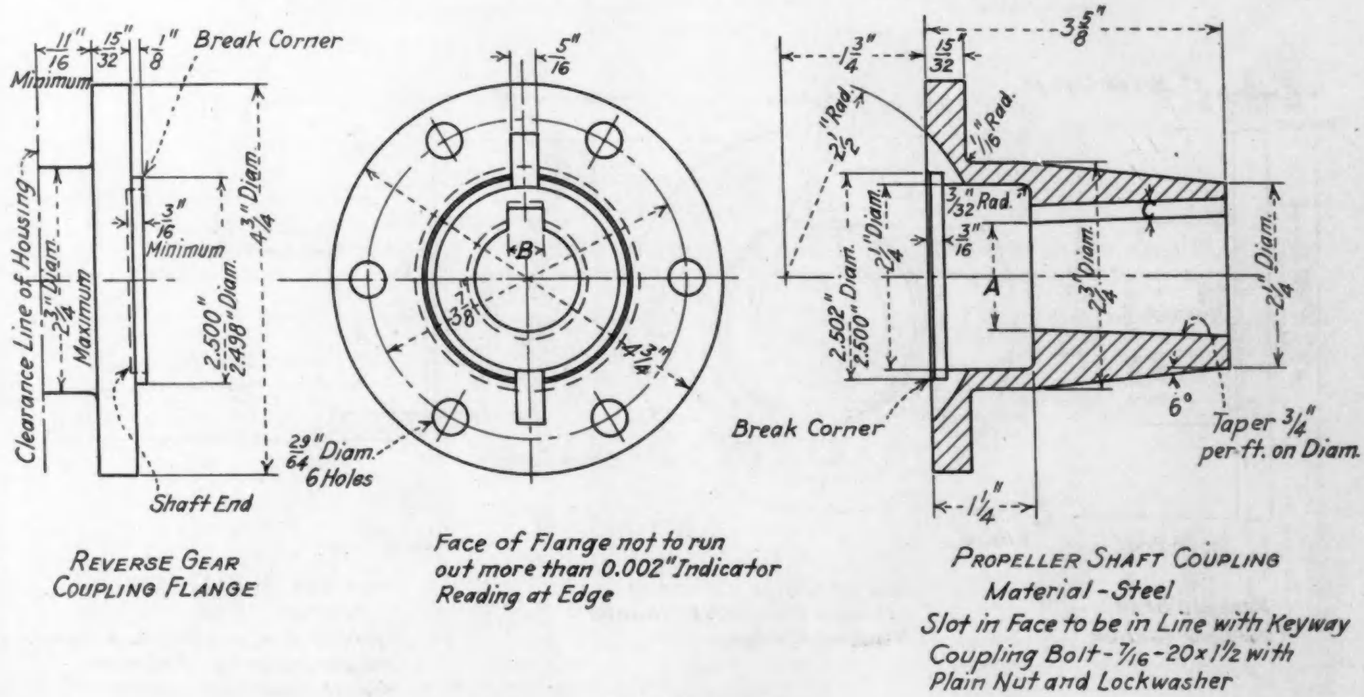
No. 1 Coupling

NO. 1—PROPELLER-SHAFT-COUPLING BORES

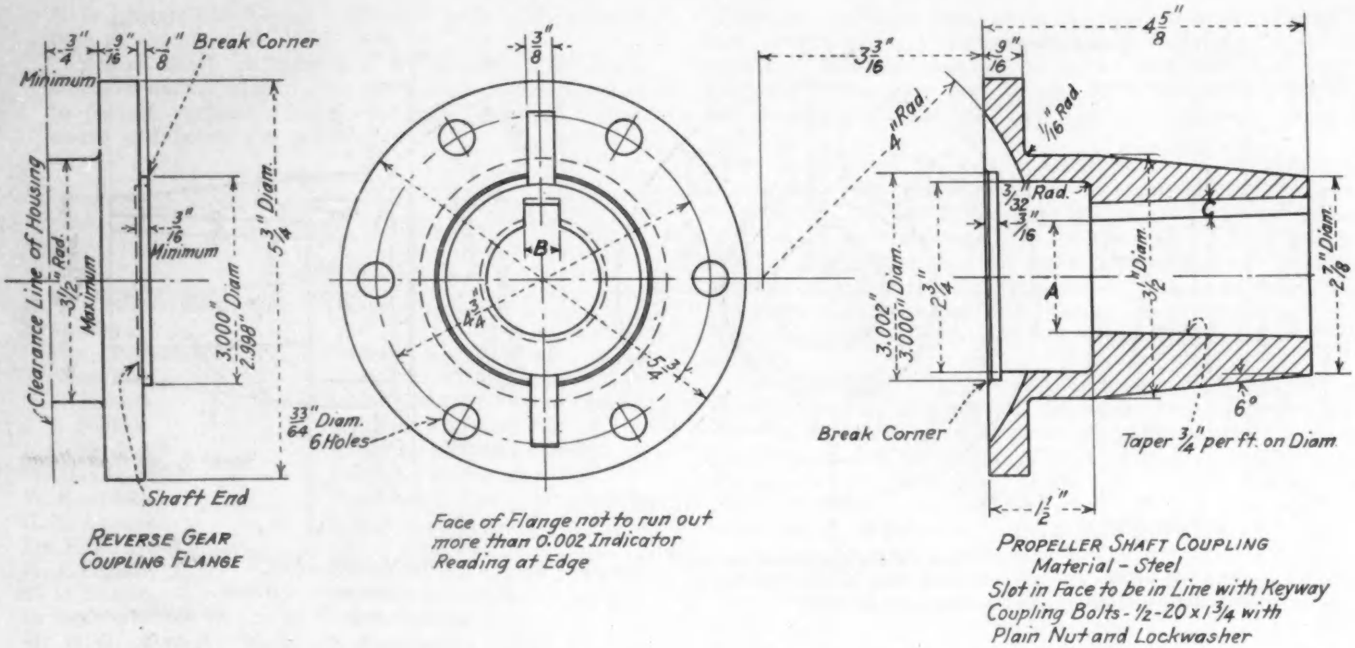
Nominal Shaft Diameter	Bore at A		Keyway Width B		Keyway Depth C	
	Min.	Max.	Min.	Max.	Min.	Max.
3/4	0.608	0.610	0.1865	0.1875	0.0953	0.0968
7/8	0.711	0.718	0.1865	0.1875	0.0953	0.0968
1	0.811	0.813	0.2490	0.2500	0.1265	0.1280
1 1/8	0.913	0.915	0.2490	0.2500	0.1265	0.1280
1 1/4	1.015	1.017	0.3115	0.3125	0.1590	0.1615

NO. 2—PROPELLER-SHAFT-COUPLING BORES

Nominal Shaft Diameter	Bore at A		Keyway Width B		Keyway Depth C	
	Min.	Max.	Min.	Max.	Min.	Max.
1 1/4	1.015	1.017	0.3115	0.3125	0.1590	0.1615
1 3/8	1.116	1.118	0.3740	0.3750	0.1905	0.1930
1 1/2	1.218	1.220	0.3740	0.3750	0.1905	0.1930
1 5/8	1.319	1.321	0.4365	0.4375	0.2217	0.2242



No. 2 Coupling



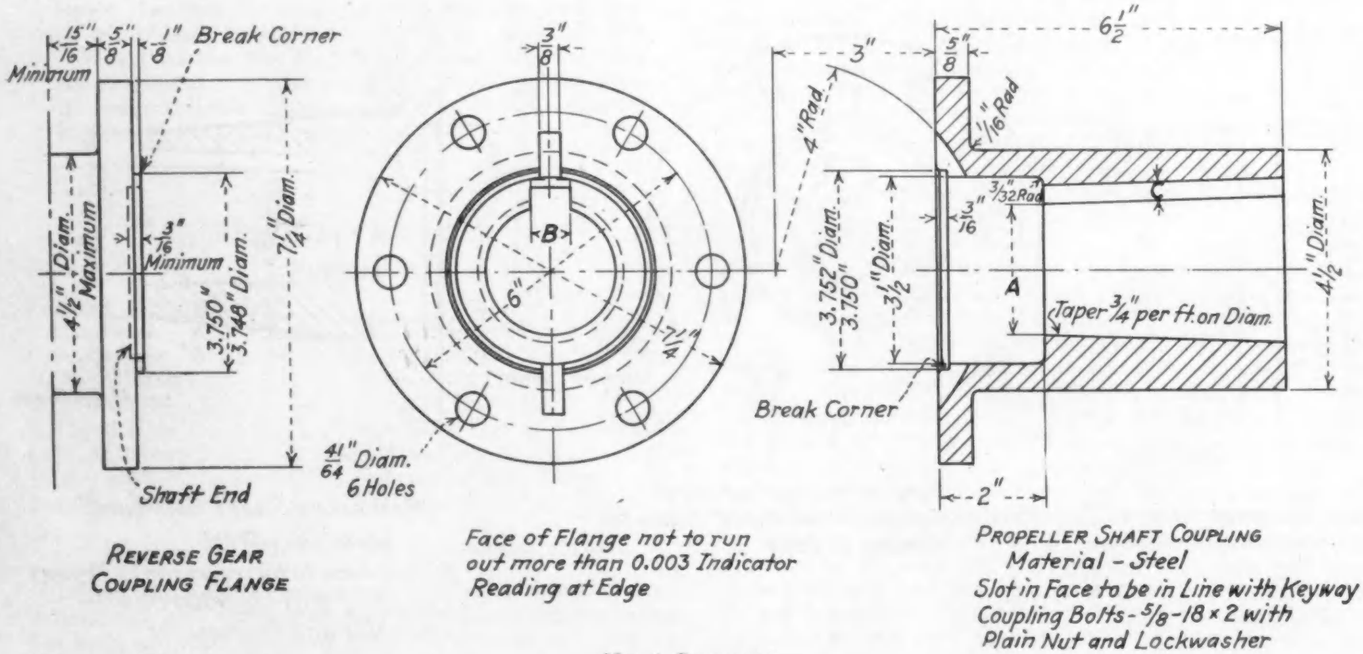
No. 3 Coupling

NO. 3—PROPELLER-SHAFT-COUPLING BORES

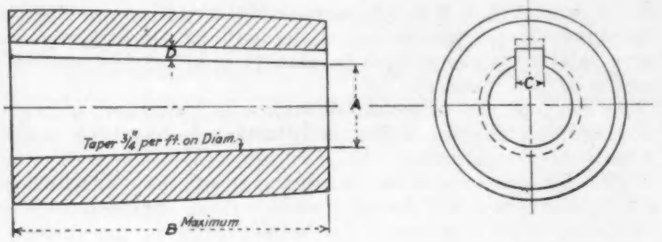
Nominal Shaft Diameter	Bore at *A*		Keyway Width *B*		Keyway Depth *C*	
	Min.	Max.	Min.	Max.	Min.	Max.
1⅝	1.319	1.321	0.4365	0.4375	0.2217	0.2242
1¾	1.421	1.423	0.4365	0.4375	0.2217	0.2242
1⅞	1.522	1.524	0.4990	0.5000	0.2530	0.2555
2	1.624	1.626	0.4990	0.5000	0.2530	0.2555

NO. 4—PROPELLER-SHAFT-COUPLING BORES

Nominal Shaft Diameter	Bore at *A*		Keyway Width *B*		Keyway Depth *C*	
	Min.	Max.	Min.	Max.	Min.	Max.
2¼	1.827	1.829	0.5610	0.5625	0.2912	0.2962
2½	2.030	2.032	0.6235	0.6250	0.3225	0.3275
2¾	2.233	2.235	0.6235	0.6250	0.3225	0.3275
3	2.437	2.439	0.7485	0.7500	0.3850	0.3900



No. 4 Coupling



MARINE PROPELLER-HUB BORES

Shaft Diameter	Bore at Small End *A*		Max. Hub Length *B*	Keyway Width *C*		Keyway Depth *D*	
	Max.	Min.		Max.	Min.	Max.	Min.
3/4	0.610	0.608	2 1/4	0.1875	0.1865	0.0968	0.0953
7/8	0.713	0.711	2 5/8	0.1875	0.1865	0.0968	0.0953
1	0.813	0.811	3	0.2500	0.2490	0.1280	0.1265
1 1/8	0.915	0.913	3 3/8	0.2500	0.2490	0.1280	0.1265
1 1/4	1.017	1.015	3 3/4	0.3125	0.3115	0.1615	0.1590
1 3/8	1.118	1.116	4 1/8	0.3750	0.3740	0.1930	0.1905
1 1/2	1.220	1.218	4 1/2	0.3750	0.3740	0.1930	0.1905
1 5/8	1.321	1.319	4 7/8	0.4375	0.4365	0.2242	0.2217
1 3/4	1.423	1.421	5 1/4	0.4375	0.4365	0.2242	0.2217
1 7/8	1.524	1.522	5 5/8	0.5000	0.4990	0.2555	0.2530
2	1.626	1.624	6	0.5000	0.4990	0.2555	0.2530
2 1/4	1.829	1.827	6 3/4	0.5625	0.5610	0.2962	0.2912
2 1/2	2.032	2.030	7 1/2	0.6250	0.6235	0.3275	0.3225
2 3/4	2.235	2.233	8 1/4	0.6250	0.6235	0.3275	0.3225
3	2.439	2.437	9	0.7500	0.7485	0.3900	0.3850

should be made by each manufacturer at the earliest time that he can do so conveniently. It may be mentioned that one thought of the Division with respect to the propeller-shaft couplings was that, should this series come into extensive enough use by various makers of marine engines, it would be possible for a supply manufacturer to make up the standard propeller-shaft couplings, in the various bores required in the different shaft sizes, in sufficient quantities to reduce the cost of these units to the engine manufacturer and make it unnecessary for him to carry an extensive stock of this item. This development must necessarily wait until these sizes come into sufficient use to make such a proposition attractive to a supply manufacturer.

The tables of dimensions on this and two preceding pages indicate a series of shaft-ends suitable for mounting of propellers and couplings in accordance with this scheme. The Division recommends the approval of these dimensions as an S.A.E. Standard.

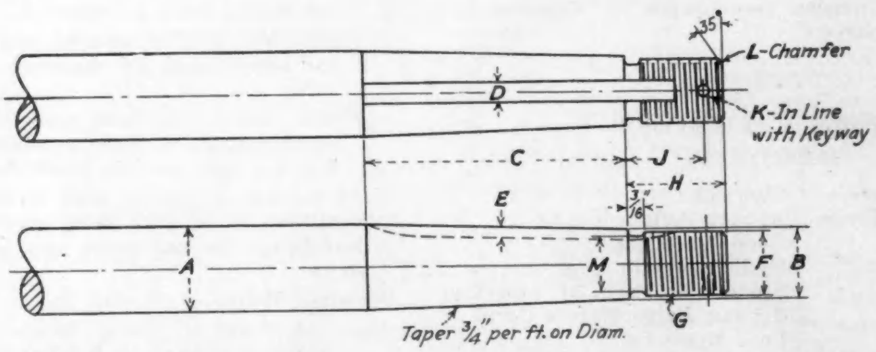
Motor-Truck Division

PERSONNEL

F. A. Whitten, *Chairman*	American Car & Foundry Co.
D. F. Myers, *Vice-Chairman*	Relay Motors Corp.
B. B. Bachman	The Autocar Co.
W. J. Baumgartner	Relay Motors Corp.
Carl J. Bock	General Motors Truck Co.
E. H. Grey	Gulf Refining Co.
Arthur W. Herrington	City of Washington
M. C. Horine	International Motor Co.
S. W. Mills	Pierce-Arrow Motor Car Co.
A. J. Scaife	White Motor Co.
A. W. Scarratt	International Harvester Co.
E. M. Schultheis	Timken Roller Bearing Co.
Ernest M. Sternberg	Sterling Motor Truck Co.

Trailer Hitches

Some criticism has been made of the trailer-hitch dimensions shown in the S.A.E. Specifications on p. 527 of the 1928 edition of the Handbook, and the question of



MARINE PROPELLER-SHAFT-END DIMENSIONS (BOTH ENDS) | COUPLING NUTS AND WASHERS

Shaft Diameter *A*	Diameter at Small End *B*		Taper Length *C*	Keyway Width *D*		Keyway Depth *E*		Outside Diameter of Threads *F*	Threads per Inch *G*	Length Threaded End *H*	Cotter Pin Hole Location *J*	Cotter Pin Hole Diameter *K*	Chamfer *L*	Under Cut Diameter *M*	Nut Size	Nut Type[1]	Width of Slot	Depth of Slot	Washer Hole Diameter	Outside Diameter of Washer	Thickness of Washer
	Max.	Min.		Max.	Min.	Max.	Min.														
3/4	0.626	0.624	2	0.1875	0.1865	0.0968	0.0953	1/2	20	1	27/32	5/32	1/32	7/16	1/2-20	Castellated	...	...	17/32	1 1/16	3/32
7/8	0.729	0.727	2 3/8	0.1875	0.1865	0.0968	0.0953	5/8	18	1 1/8	15/16	3/16	3/64	35/64	5/8-18	Castellated	...	...	21/32	1 5/16	3/32
1	0.829	0.827	2 3/4	0.2500	0.2499	0.1280	0.1265	3/4	16	1 1/8	15/16	3/16	3/64	21/32	3/4-16	Slotted	5/32	1/4	13/16	1 1/2	1/8
1 1/8	0.931	0.929	3 1/8	0.2500	0.2499	0.1280	0.1265	3/4	16	1 1/8	15/16	3/16	3/64	21/32	3/4-16	Slotted	5/32	1/4	13/16	1 1/2	1/8
1 1/4	1.033	1.031	3 1/2	0.3125	0.3115	0.1615	0.1590	3/4	16	1 1/8	15/16	3/16	3/64	21/32	3/4-16	Slotted	5/32	1/4	13/16	1 1/2	1/8
1 3/8	1.134	1.132	3 7/8	0.3750	0.3740	0.1930	0.1905	1	14	1 3/8	1 5/32	7/32	3/64	29/32	1 -14	Slotted	3/16	9/32	1 1/16	2	1/8
1 1/2	1.236	1.234	4 1/4	0.3750	0.3740	0.1930	0.1905	1	14	1 3/8	1 5/32	7/32	3/64	29/32	1 -14	Slotted	3/16	9/32	1 1/16	2	1/8
1 5/8	1.337	1.335	4 5/8	0.4375	0.4365	0.2242	0.2217	1	14	1 3/8	1 5/32	7/32	3/64	29/32	1 14	Slotted	3/16	9/32	1 1/16	2	1/8
1 3/4	1.439	1.437	5	0.4375	0.4365	0.2242	0.2217	1 1/4	12	1 5/8	1 3/8	1/4	1/16	1 1/8	1 1/4-12	Slotted	7/32	5/16	1 5/16	2 1/2	5/32
1 7/8	1.540	1.538	5 3/8	0.5000	0.4990	0.2555	0.2530	1 1/4	12	1 5/8	1 3/8	1/4	1/16	1 1/8	1 1/4-12	Slotted	7/32	5/16	1 5/16	2 1/2	5/32
2	1.642	1.640	5 3/4	0.5000	0.4990	0.2555	0.2530	1 1/4	12	1 5/8	1 3/8	1/4	1/16	1 1/8	1 1/4-12	Slotted	7/32	5/16	1 5/16	2 1/2	5/32
2 1/4	1.845	1.843	6 1/2	0.5625	0.5610	0.2962	0.2912	1 1/2	12	1 7/8	1 19/32	9/32	1/16	1 3/8	1 1/2-12	Slotted	1/4	3/8	1 9/16	3	5/32
2 1/2	2.048	2.046	7 1/4	0.6250	0.6235	0.3275	0.3225	1 1/2	12	1 7/8	1 19/32	9/32	1/16	1 3/8	1 1/2-12	Slotted	1/4	3/8	1 9/16	3	5/32
2 3/4	2.251	2.249	8	0.6250	0.6235	0.3275	0.3225	1 3/4	12	2 1/16	1 25/32	9/32	1/16	1 3/8	1 3/4-12	Slotted	1/4	3/8	1 13/16	3 1/4	5/32
3	2.455	2.453	8 3/4	0.7500	0.7485	0.3900	0.3850	1 3/4	12	2 1/16	1 25/32	9/32	1/16	1 3/8	1 3/4-12	Slotted	1/4	3/8	1 13/16	3 1/4	5/32

Thread tolerances to be Class 3 (medium fit) American standard.

[1] Nut type—castellated (tentative American standard); slotted, 3/4-16 to 1 1/2-12 incl.—use hexagonal plain nuts, (tentative American standard) and slot as specified; slotted, 1 3/4-12—width across flats, 2 1/4; thickness, 1 1/16; slot as specified.

revising this came up for the consideration of the Division. It was felt advisable, however, to cancel the present specification pending its revision by a Subdivision to be appointed for this work, and the Division therefore recommends that the present S.A.E. Specification on Trailer Hitches be cancelled and the subject submitted to a Subdivision for development of new specifications.

Motor-Truck Bodies and Cabs

The present S.A.E. Recommended Practices on Motor-Truck Bodies and Motor-Truck Cabs, pp. 333 and 334 of the 1928 edition of the Handbook, were submitted to truck manufacturers in a survey to determine the extent of their use. The results indicated that present practice varied greatly from these recommended practices, and that very little use is made of them at present.

A proposal to cancel these two specifications was submitted to the Division by letter-ballot, the majority voting in favor of cancelling them. The Division therefore recommends that the said specifications on Motor-Truck Bodies and Motor-Truck Cabs be cancelled.

Motor-Truck Dump-Bodies

Considerable frame breakage on motor-trucks has been experienced in the past because of the use of gravity dump-bodies of large capacity. At a meeting of truck and dump-body manufacturers, called to consider this situation, it was suggested that the Society approve a recommendation as to the maximum size of dump-body which should be gravity operated, and a request was made that the Motor-Truck Division consider the approval of the following as an S.A.E. Recommended Practice:

AUTOMATIC DUMP-BODIES

(*S.A.E. Recommended Practice*)

Dump-bodies of a capacity greater than 1½ cu. yd. shall be hand-hoist or power-hoist operated.

This has been submitted to the Motor-Truck Division and approved, and the Division recommends its approval by the Standards Committee.

Passenger-Car Division

PERSONNEL

G. L. McCain, *Chairman*	Chrysler Corp.
H. C. Snow, *Vice-Chairman*	Auburn Automobile Co.
R. S. Begg	Budd Wheel Co.
S. R. Castor	H. H. Franklin Mfg. Co.
L. A. Chaminade	Studebaker Corp. of America
C. A. Delaney	Graham-Paige Motors Corp.
W. T. Fishleigh	Ford Motor Co.
W. H. Graves	Packard Motor Car Co.
J. B. Judkins	J. B. Judkins Co.
E. H. Nolleau	E. I. duPont deNemours & Co.
Ivan Ornberg	Hupp Motor Car Corp.
G. W. Smith	Buick Motor Co.

Leaf Springs

For some months a Subdivision of the Passenger-Car Division has been formulating a revision of the present Leaf-Spring Specifications, pp. 309 to 319 inclusive of the 1928 edition of the S.A.E. Handbook. It has recommended that the following existing standards and recommended practices be cancelled: Leaf-Spring Nomenclature, Leaf Points, Finish of Springs, Wrapped Spring-Eyes, Leaf-Spring Definitions, Leaf-Spring Nibs and Shrunk Center-Bands.

The present specifications on Tests for Parallelism of Spring Eyes, Spring-Eye Bushings and Width of Spring-Ends have been incorporated in the proposed recommended practice. The present S.A.E. Standard on Spring Center-Bolts and the S.A.E. Recommended Practice on Spring Rebound-Clips, Spacers and Bolts will be slightly revised at a later date to conform to present practice and requirements of the industry.

As part of the proposed recommended practice, a Leaf-Spring Specification Form, as illustrated, has been made a part of the specification.

The Division recommends approval of the cancellation noted, and the revisions and additions as included in the following report, which is to be approved in its entirety as an S.A.E. Recommended Practice:

LEAF-SPRINGS

All letter dimensions refer to the Leaf-Spring Specification Form herewith.

Load.—Load is the force in pounds to be applied by the testing machine to the spring in question. Load is to be read on the testing machine after rapping the spring.

Height.—See dimension *E*.

Clearance.—Clearance is the greatest distance in inches the spring may deflect after the specified load has been applied.

Opening.—See dimension *F*. Where the exposed surface of the main leaf comes below the center line of the spring eyes, when the spring is in the position illustrated, the dimension *F* shall be expressed as a minus quantity.

Rate (or Flexibility.)—Rate is ½ the force, measured in pounds, necessary to deflect the spring from *F* plus 1 in. to *F* minus 1 in.

Finish.—Finish refers to the surface condition of the steel after heat-treatments.

Finish No. 1.—Leaves shall be left in the same condition as that in which they come from the heat-treating process.

Finish No. 2.—All burrs on the bearing sides of the leaves shall be removed.

Finish No. 3.—The sheared and trimmed edges of the leaves shall be chamfered on their bearing sides.

Finish No. 4.—All loose scale shall be removed.

Combinations of these numbers may be used to indicate the complete finish desired.

Leaf Numbers.—Leaves shall be designated by their numbers, No. 1 leaf being the main leaf; No. 2 leaf being the leaf above and adjacent to it; and so on.

Nominal Width of Spring Steel.—See dimension *G*.

Finished Width of Spring Steel.—See dimension *H*.

Spring-ends shall be finished to a width of 1/16 in. less than the nominal width of the springs, with a plus or minus tolerance of 0.005 in. for passenger-cars and 0.010 in. for motor-trucks, to a point far enough back on the spring to allow free shackle-movement or free sliding movement in case of flat-end springs.

Spring Eyes and Bushings.—See dimensions *K* and *L*.

TOLERANCES ON SPRING EYES AND BUSHINGS

Part	Diameter	Tolerance, In.
Bushed eyes	−0.001	−0.003
Unbushed eyes	+0.001	−0.004

The nominal wall-thickness of spring-eye bushings shall be ⅛ in. for all sizes of bushing.

LEAF-SPRING STEEL

Rolling Tolerances for Automobile Concave Spring-Steel.—The finished bars shall be of double-concave section with round edges. The radii of the

TABLE 1—WIDTH AND THICKNESS TOLERANCES

Width of Flat, In.		Width, In.		Thickness,[1] In.	
Over	To, Inclusive	Plus	Minus	Plus	Minus
0	2¼	1/32	0	0.005	0.005
2¼	3	3/64	0	0.006	0.006
3	5	1/16	0	0.007	0.007

[1] Thickness measurements shall be taken at the edge of the bar where the concave surface intersects the rounded edge.

arcs of the two concave surfaces shall be of equal length.

Rolls to produce the round edges shall be turned to a radius equal to two-thirds the thickness of the bar.

All bars ordered to gage shall be rolled to the Birmingham wire gage.

All bars must meet the width and thickness tolerances specified in Table 1.

The difference in thickness between the two edges of each bar shall not be greater than those given in Table 2.

TABLE 2—DIFFERENCES IN THICKNESS

Width of Flat In.		Difference in Thickness, In.
Over	To, Inclusive	
0	2	0.002
2	3	0.003
3	5	0.003

Leaf-spring steel bars shall not have more than 1-in. curvature in 20 ft., or 1¼ in. in 25 ft., or 1½ in. in 30 ft.

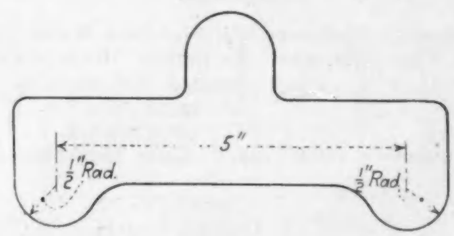
The concavity, or difference between the thickness at the edges and at the center of the bar, shall be as specified in Table 3.

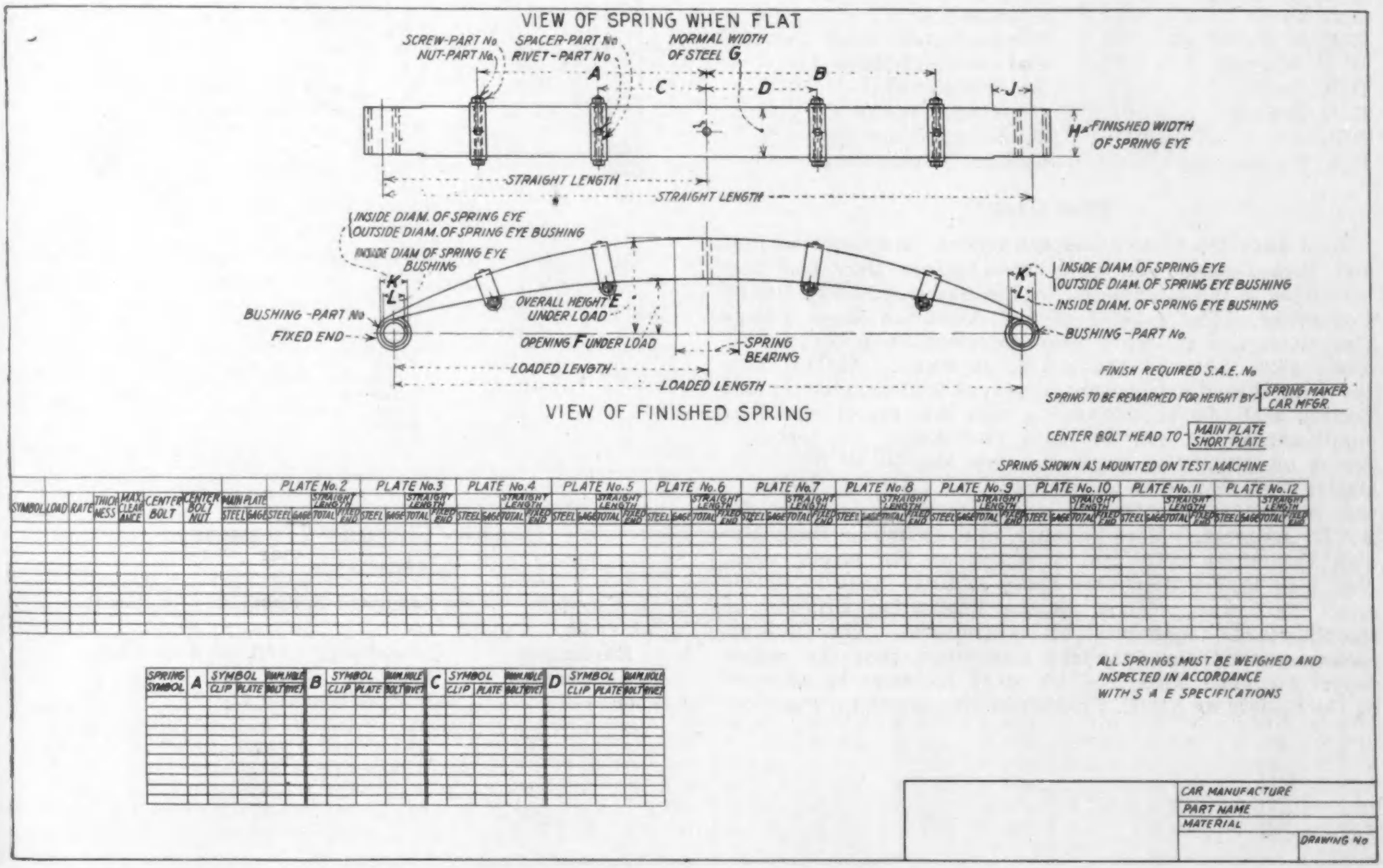
TABLE 3—ALLOWABLE VARIATIONS IN CONCAVITY

Width, In.	Nominal Concavity, In.	Maximum Concavity, In.	Minimum Concavity, In.
1½	0.007	0.009	0.004
1¾	0.008	0.010	0.005
2	0.010	0.012	0.006
2¼	0.011	0.013	0.007
2½	0.013	0.015	0.009
3	0.016	0.018	0.012
3½	0.018	0.020	0.013
4	0.021	0.023	0.016
5	0.029	0.031	0.023

LEAF-SPRING TESTS

All leaf-springs shall be tested in an upright position and supported so as to permit free movement.



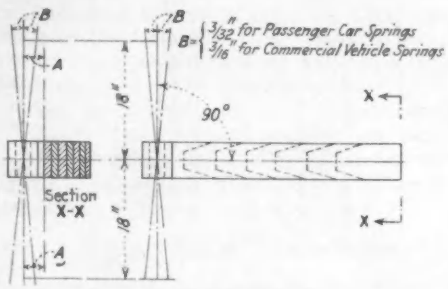


All tests or inspection measurements shall be made after rapping the leaf-spring in the test or inspection position.

TESTS FOR PARALLELISM OF SPRING EYES

Eyes of main leaves shall be parallel and square (within specified limits) to the main leaf and parallel to each other.

The test shall be made by inserting two 3-ft. bars in the eyes as shown.



Production Division

PERSONNEL

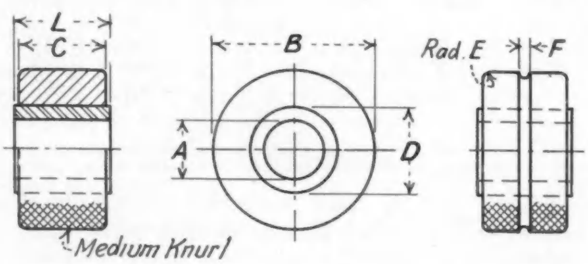
LeRoy F. Maurer, *Chairman*	Pierce-Arrow Motor Car Co.
F. W. Stein, *Vice-Chairman*	Fairbanks, Morse & Co.
David Ayr	Pratt & Whitney Co.
F. M. Bender	Lycoming Mfg. Co.
Joseph Berge	The Crowner Co.
Eugene Bouton	J. I. Case Threshing Machine Co.
A. De Vlieg	Chrysler Corp.
A. R. Fors	Continental Motors Corp.
H. P. Harrison	H. H. Franklin Mfg. Co.
O. C. Kavle	Syracuse, N. Y.
F. E. A. Klein	Pierce-Arrow Motor Car Co.
W. P. Mitchell	International Motor Co.
D. W. Ovaitt	Buick Motor Co.
E. N. Sawyer	Cleveland Tractor Co.
William C. Thiel	Waukesha Motor Co.
E. K. Wennerlund	General Motors Corp.

RING GAGES

Last June the Society adopted reports on cylindrical plug and thread-gages and ring thread-gages that had been submitted to it for approval by the American Gage Design Committee. The genesis of the American Gage Design Committee and its work were described on p. 721 of the June, 1928, issue of the S.A.E. JOURNAL. At this time the ring thread-gages were approved and adopted by the Society with the understanding that this report would be supplemented by one on plain ring-gages. A tentative report on plain ring-gages in sizes No. 00 to No. 5 inclusive for diameters above 0.059 to 1.510 in. inclusive was printed on p. 217 of the August, 1928, issue of the S.A.E. JOURNAL. More recently, the American Gage Design Committee submitted a report on the larger sizes, Nos. 6 to 11, for diameters above 1.510 to 4.510 in. inclusive. This was referred to the Production Division of the Standards Committee for its approval. The Division recommends to the Standard Committee that the entire report for gage sizes Nos. 00 to 11 inclusive be adopted by the Society as S.A.E. Production Recommended Practice.

PLAIN CYLINDRICAL RING-GAGES

(Proposed S.A.E. Recommended Practice)

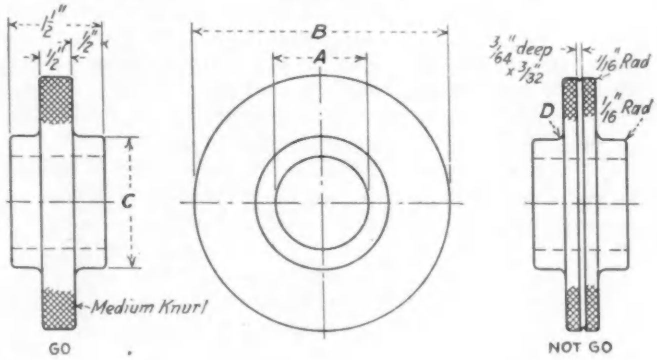


Gage Size	Range A		B ±0.010	C ±0.010	D[1]	Radius E	Groove F[2]	Bushing[3] L
	Above	Including						
00	0.059	0.150	15/16	3/16	3/8	1/32	1/32	1/4
0	0.150	0.240	15/16	3/8	7/16	1/32	1/16	7/16
1	0.240	0.365	1 1/8	9/16	9/16	1/16	3/32	5/8
2	0.365	0.510	1 3/8	3/4	3/4	1/16	3/32	13/16
3	0.510	0.825	1 3/4	15/16	...	3/32	3/32	...
4	0.825	1.135	2 1/8	1 1/8	...	3/32	3/32	...
5	1.135	1.510	2 1/2	1 5/16	...	3/32	3/32	...

[1] Tolerance on hole for bushing, +0.000, —0.005 in. Bushing diameter, $D + 0.020$ in., to allow for fitting. No bushing used in sizes No. 3 and larger.

[2] Groove F depth to be one-half of groove width.

[3] Bushings to be 1/16 in. longer than ring thickness, but ground flush after hole is finished.



Gage Ring	Range A		Diameter		Radius
	Above	Including	B	C	D
6	1.510	2.010	4 1/8	A + 7/8	1/8
7	2.010	2.510	4 5/8	A + 7/8	1/8
8	2.510	3.010	5 1/2	A + 1	3/16
9	3.010	3.510	6	A + 1	3/16
10	3.510	4.010	6 7/8	A + 1 1/8	1/4
11	4.010	4.510	7 3/8	A + 1 1/8	1/4

Screw-Threads Division

PERSONNEL

E. H. Ehrman, *Chairman*	Standard Screw Co.
K. L. Herrmann, *Vice-Chairman*	Studebaker Corp. of America
A. Boor	Willys-Overland Co.

E. J. Bryant	Greenfield Tap & Die Corp.
Earle Buckingham	Massachusetts Institute of Technology
Ellwood Burdsall	Russell, Burdsall & Ward Bolt & Nut Co.
Luther D. Burlingame	Brown & Sharpe Mfg. Co.
George S. Case	Lamson & Sessions
R. M. Heames	Victor Peninsular Co.
J. K. Olsen	Stewart-Warner Speedometer Corp.
D. W. Ovaitt	Buick Motor Co.
O. B. Zimmerman	International Harvester Co.
B. M. Smarr	General Motors Corp.

Round Unslotted-Head Bolts

In January, 1927, a Sectional Committee report on Round Unslotted-Head Bolts was approved by the Standards Committee of the Society as one of the sponsors of the Sectional Committee, but no effort was made at that time to submit the report for approval as an S.A.E. Standard. Following this, a survey of the automotive industry was undertaken to determine which types and sizes are used in the industry, and the data were submitted to a Subdivision of the Screw-Threads Division for decision as to what types and sizes should become an S.A.E. Standard. The Subdivision report recommended that the entire specifications on all types, excluding the tables on bolt lengths and thread lengths, should be approved by the Screw-Threads Division as S.A.E. Standards, and the Division has approved this recommendation by letter-ballot.

The Division therefore recommends that the American Standards on Round Unslotted-Head Bolts shown on this and the two following pages be adopted as S.A.E. Standards.

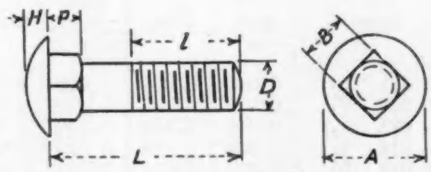


TABLE 1—SQUARE-NECK CARRIAGE-BOLT

Nominal Size	*D* Major Diameter of Thread		Threads per Inch	*A* Diameter of Head		*H* Height of Head		*P* Depth of Square		*B* Width of Square	
	Maximum Basic	Tolerance −		Basic	Tolerance + or −	Basic	Tolerance + or −	Basic	Tolerance +	Basic	Tolerance −
No. 10	0.190	0.009	24	0.438 (7/16)	0.010	0.094	0.010	0.188	0.031	0.190	0.009
1/4	0.250	0.010	20	0.563 (9/16)	0.010	0.125	0.010	0.219	0.031	0.250	0.010
5/16	0.313	0.013	18	0.688 (11/16)	0.010	0.156	0.010	0.250	0.031	0.313	0.013
3/8	0.375	0.015	16	0.813 (13/16)	0.010	0.188	0.010	0.281	0.031	0.375	0.015
7/16	0.438	0.015	14	0.938 (15/16)	0.010	0.219	0.010	0.313	0.031	0.438	0.015
1/2	0.500	0.015	13	1.063 (1 1/16)	0.010	0.250	0.010	0.344	0.031	0.500	0.015
9/16	0.563	0.016	12	1.188 (1 3/16)	0.015	0.281	0.015	0.375	0.031	0.563	0.016
5/8	0.625	0.017	11	1.313 (1 5/16)	0.015	0.313	0.015	0.406	0.031	0.625	0.017
3/4	0.750	0.020	10	1.563 (1 9/16)	0.015	0.375	0.015	0.469	0.031	0.750	0.020

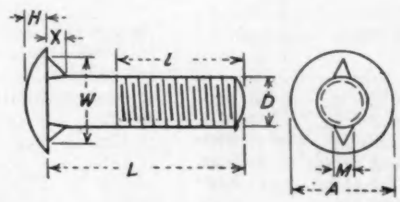


TABLE 2—FIN-NECK CARRIAGE-BOLT

Nominal Size	*D* Major Diameter of Thread		Threads per Inch	*A* Diameter of Head		*H* Height of Head		*X* Depth of Fins		*W* Distance Across Fins		*M* Maximum Thickness of Fins	
	Maximum Basic	Tolerance −		Basic	Tolerance + or −	Basic	Tolerance + or −	Basic	Tolerance +	Basic	Tolerance + or −	Basic	Tolerance + or −
No. 10	0.190	0.009	24	0.469 (15/32)	0.010	0.078	0.010	0.078	0.010	0.375	0.010	0.078	0.010
1/4	0.250	0.010	20	0.594 (19/32)	0.010	0.109	0.010	0.094	0.010	0.438	0.010	0.094	0.010
5/16	0.313	0.013	18	0.719 (23/32)	0.010	0.141	0.010	0.125	0.010	0.531	0.010	0.125	0.010
3/8	0.375	0.015	16	0.844 (27/32)	0.010	0.172	0.010	0.141	0.010	0.625	0.010	0.141	0.010
7/16	0.438	0.015	14	0.969 (31/32)	0.010	0.203	0.010	0.172	0.010	0.719	0.010	0.172	0.010
1/2	0.500	0.015	13	1.094 (1 3/32)	0.010	0.234	0.010	0.188	0.010	0.813	0.010	0.188	0.010

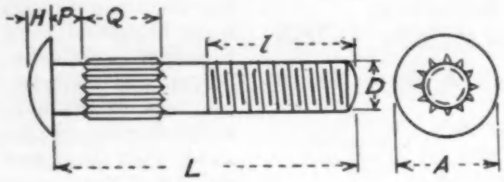


TABLE 3—RIBBED CARRIAGE-BOLT

Nominal Size	D		Threads per Inch	A		H		P		Q		Maximum Number of Ribs	Included Angle of Rib
	Major Diameter of Thread			Diameter of Head		Height of Head		Distance of Rib Below Head		Length of Rib			
	Maximum Basic	Tolerance −		Basic	Tolerance + or −	Basic	Tolerance + or −	Basic	Tolerance + or −	When L is 1⅛ In. and Under	When L is 1¼ In. and Over		
No. 10	0.190	0.009	24	0.438 (7/16)	0.010	0.094	0.010	0.094	0.031	0.375	0.500	9	Approximately 90 Deg.
¼	0.250	0.010	20	0.563 (9/16)	0.010	0.125	0.010	0.094	0.031	0.375	0.500	10	
5/16	0.313	0.013	18	0.688 (11/16)	0.010	0.156	0.010	0.094	0.031	0.375	0.500	12	
⅜	0.375	0.015	16	0.813 (13/16)	0.010	0.188	0.010	0.094	0.031	0.375	0.500	12	
7/16	0.438	0.015	14	0.938 (15/16)	0.010	0.219	0.010	0.094	0.031	0.375	0.500	14	
½	0.500	0.015	13	1.063 (1 1/16)	0.010	0.250	0.010	0.094	0.031	0.375	0.500	16	

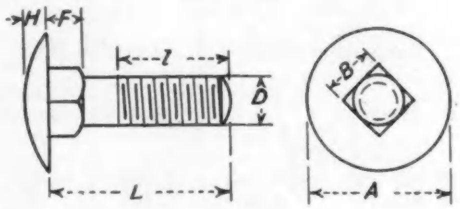


TABLE 4—STEP-BOLT

Nominal Size	D		Threads per Inch	A		H		P		B	
	Major Diameter of Thread			Diameter of Head		Height of Head		Depth of Square		Width of Square	
	Maximum Basic	Tolerance −		Basic	Tolerance + or −	Basic	Tolerance + or −	Basic	Tolerance +	Basic	Tolerance −
No. 10	0.190	0.009	24	0.625 (⅝)	0.010	0.094	0.010	0.188	0.031	0.190	0.009
¼	0.250	0.010	20	0.813 (13/16)	0.010	0.125	0.010	0.219	0.031	0.250	0.010
5/16	0.313	0.013	18	1.000 (1)	0.010	0.156	0.010	0.250	0.031	0.313	0.013
⅜	0.375	0.015	16	1.188 (1 3/16)	0.010	0.188	0.010	0.281	0.031	0.375	0.015
7/16	0.438	0.015	14	1.375 (1⅜)	0.010	0.219	0.010	0.313	0.031	0.438	0.015
½	0.500	0.015	13	1.563 (1 9/16)	0.010	0.250	0.010	0.344	0.031	0.500	0.015

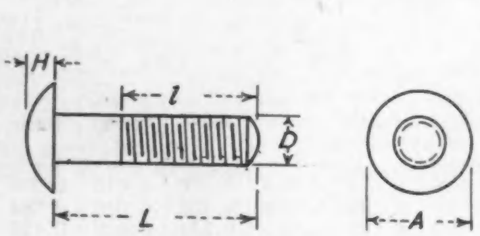


TABLE 5—BUTTON-HEAD MACHINE BOLT

Nominal Size	D		Threads per Inch	A		H	
	Major Diameter of Thread			Diameter of Head		Height of Head	
	Maximum Basic	Tolerance −		Basic	Tolerance + or −	Basic	Tolerance + or −
No. 10	0.190	0.009	24	0.438 (7/16)	0.010	0.094	0.010
¼	0.250	0.010	20	0.563 (9/16)	0.010	0.125	0.010
5/16	0.313	0.013	18	0.688 (11/16)	0.010	0.156	0.010
⅜	0.375	0.015	16	0.813 (13/16)	0.010	0.188	0.010
7/16	0.438	0.015	14	0.938 (15/16)	0.010	0.219	0.010
½	0.500	0.015	13	1.063 (1 1/16)	0.010	0.250	0.010
9/16	0.563	0.016	12	1.188 (1 3/16)	0.015	0.281	0.015
⅝	0.625	0.017	11	1.313 (1 5/16)	0.015	0.313	0.015
¾	0.750	0.020	10	1.563 (1 9/16)	0.015	0.375	0.015

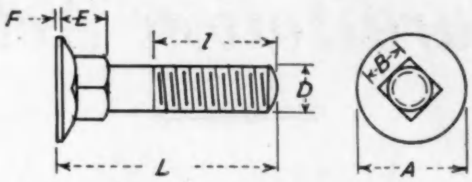


TABLE 6—COUNTERSUNK CARRIAGE-BOLT

Nominal Size	D Major Diameter of Thread: Maximum Basic	D Major Diameter of Thread: Tolerance −	Threads per Inch	A Diameter of Head: Basic	A Diameter of Head: Tolerance + or −	F Feed Thickness	Included Angle, Deg.	E Depth of Square: Basic	E Depth of Square: Tolerance +	B Width of Square: Basic	B Width of Square: Tolerance −
No. 10	.....	.....	....	....	.....	.....	....	.....	.....	.....	.....
¼	0.250	0.010	20	0.625 (⅝)	0.010	0.016	114	0.281	0.031	0.250	0.010
5/16	0.313	0.013	18	0.750 (¾)	0.010	0.031	114	0.344	0.031	0.313	0.013
⅜	0.375	0.015	16	0.875 (⅞)	0.010	0.031	114	0.406	0.031	0.375	0.015
7/16	0.438	0.015	14	1.000 (1)	0.010	0.031	114	0.469	0.031	0.438	0.015
½	0.500	0.015	13	1.125 (1⅛)	0.010	0.031	114	0.531	0.031	0.500	0.015
9/16	0.563	0.016	12	1.250 (1¼)	0.015	0.031	114	0.594	0.031	0.563	0.016
⅝	0.625	0.017	11	1.375 (1⅜)	0.015	0.031	114	0.656	0.031	0.625	0.017
¾	0.750	0.020	10	1.625 (1⅝)	0.015	0.047	114	0.781	0.031	0.750	0.020

Transmission Division

PERSONNEL

S. O. White, *Chairman*	Warner Gear Co.
P. L. Tenney, *Vice-Chairman*	General Motors Corp.
A. C. Bryan	Durston Gear Corp.
E. R. Fish	Brown-Lipe Gear Co.
L. C. Fuller	Kalamazoo, Mich.
D. E. Gamble	Bork & Beck Co.
K. L. Herrmann	Studebaker Corp. of America
D. F. Myers	Relay Motors Corp.
B. S. Pfeiffer	Magee-Pfeiffer Co.
H. W. Sweet	Chrysler Corp.
C. E. Swenson	Mechanics Universal Joint Co.
H. T. Woolson	Chrysler Corp.

CONTROL AND GEARSHIFT POSITIONS

With the development of four-speed-transmission gearshifts in American passenger-cars, the Transmission Division considered the advisability of providing for standard positions in the present S.A.E. Standard printed on p. 65 of the HANDBOOK. Information gathered in England for the Society as to the four-speed gearshift positions used in foreign cars at that time indicated a wide variety. Upon further study of the matter and comparison with the present S.A.E. Standard positions, it was felt that the four-speed positions specified for motor-truck transmissions is most acceptable. Incidentally, it was indicated at the Division meeting that the selection of these positions coincides with the recently adopted British Standard.

The Transmission Division therefore recommends that in the present S.A.E. Standard the caption for the four-speed truck-transmissions and the note on four-speed gearshift positions be revised by omitting the word "truck" in the caption and the words "for motor-trucks" in the note on p. 65 of the S.A.E. HANDBOOK.

FLYWHEEL AND CLUTCH HOUSINGS

Some time ago the question was raised in the Transmission Division whether the tolerance between the limits for the outside diameter of the clutch driving-member could not be increased. Investigation indicated that in general the engine manufacturers do not, while the clutch manufacturers do, favor changing the present tolerance to give more leeway in manufacture. The Division decided that, as no particular trouble is being experienced with the present tolerance and as danger from eccentricity in the drum mounting is increased in the modern higher-speed engines, it would not be wise to increase the tolerance. At the time this matter was being considered, the Division referred the standardization of the clutch driving-member bolt-hole diameters to the manufacturers, whose replies indicated that the 13/32-in. diameter was favored.

The Transmission Division therefore recommends that the following sentence be added under the caption of Clutch Housings on p. 2 of the present edition of the HANDBOOK:

> The diameter of the bolt holes in the clutch driving-member shall be 13/32 in.

CLUTCH FACINGS

At the time the present S.A.E. Recommended Practice was last revised, consideration was given to specifying definite limits for parallelism of clutch facings, but it was felt that it was not feasible to do so. The matter was again brought to the attention of the Transmission Division, and at its meeting in Detroit last November it was felt that something should be noted in the present S.A.E. Recommended Practice, as a matter of information, as to satisfactory practice with regard to specifying the parallelism of the faces of clutch facings.

The Division therefore recommends that, in the notes supplementing the tables, the dimensions for multiple-disc and single-plate clutch-facing sizes in the S.A.E. Recommended Practice on p. 62 of the 1928 edition of the S.A.E. HANDBOOK be revised by omitting the sentence "Limits do not apply to parallelism of the faces" and adding the following:

> Limits do not apply to parallelism of the faces but limits for parallelism in present practice range from 0.002 to 0.005 in.

Standardization Activities

Milling-Cutters and Arbors

Report on Keys and Keyways to Be Approved by Sectional Committee for American Standard

ONE of the more important tool-standardization projects before the Sectional Committee on Small Tools and Machine-Tool Elements that is sponsored by the Society, the American Society of Mechanical Engineers and the National Machine Tool Builders Association under the procedure of the American Standards Association, is milling-cutters. A comprehensive report on the proposed standard diameters and widths of the milling-cutters of 15 types was printed in the November, 1928, issue of the S.A.E. JOURNAL commencing on p. 504. Previously reports were printed on p. 321 of the March, 1928, issue and p. 712 of the June, 1927, issue. The following correction in the dimensioning of the drawing for the shell end mills shown with table No. 15 on p. 509 of the November, 1928, S.A.E. JOURNAL should be noted:

Diameter *F* should be for the small end of the taper bore and diameter *G* should be shown for the outside diameter of the finished face at the bottom of the taper bore.

The Subcommittee which prepared these reports has submitted its final report on Keys and Keyways for Milling-Cutters and Arbors, as given in the accompanying illustration and table.

In submitting its report for circularization the Subcommittee states:

The basic sizes are the same as submitted by the Subcommittee in January, 1928, (S.A.E. JOURNAL, March, 1928, p. 321). While the new proposal makes no change in the width of the keyseat and only a slight modification in the depth of the keyseat in both the arbor and the cutter, it definitely establishes a new set of limits that have been approved by the Sub-Group on Limits.

The report is published to afford production engineers throughout the industry an opportunity to review it before it is submitted to the Sectional Committee as a whole and to the sponsors for final approval. The Society's representatives on the Subcommittee that prepared this report are H. P. Harrison, of the H. H. Franklin Mfg. Co., and D. W. Ovaitt, of the Buick Motor Car Co. The Society requests particularly that the production engineers, after reviewing the report, submit any comments they wish to make to the Society's Standards Department as promptly as possible.

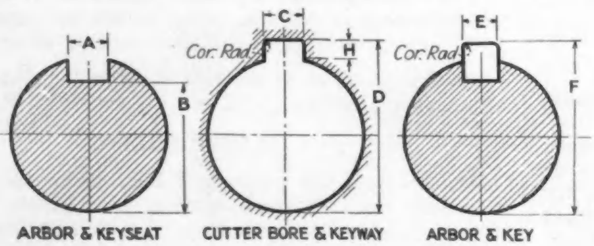


Table No. 1. Keyseat, Keyway and Key Dimensions.

Diam. Arbor	Nom. Width of Key	Arbor and Keyseat				Bore and Keyway[1]					Arbor and Key[1]			
		A Max.	A Min.	B Max.	B Min.	C Max.	C Min.	D Min.	H Nom.	Cor. Rad.	E Max.	E Min.	F Max.	F Min.
1/2	3/32	.0947	.0937	.4531	.4481	.106	.099	.5578	3/64	020	.0932	.0927	.5468	.5408
5/8	1/8	.126	.125	.5625	.5575	.137	.130	.6985	1/16	1/32	.1245	.1240	.6875	.6815
3/4	1/8	.126	.125	.6875	.6825	.137	.130	.8225	1/16	1/32	.1245	.1240	.8125	.8065
7/8	1/8	.126	.125	.8125	.8075	.137	.130	.9475	1/16	1/32	.1245	.1240	.9375	.9315
1	1/4	.251	.250	.8438	.8388	.262	.255	1.104	3/32	3/64	.2495	.2490	1.094	1.088
1 1/4	5/16	.3135	.3125	1.063	1.058	.325	.318	1.385	1/8	1/16	.3120	.3115	1.375	1.369
1 1/2	3/8	.376	.375	1.281	1.276	.410	.385	1.666	5/32	1/16	.3745	.3740	1.656	1.650
1 3/4	7/16	.4385	.4375	1.500	1.495	.473	.448	1.948	3/16	1/16	.4370	.4365	1.938	1.932
2	1/2	.501	.500	1.687	1.682	.535	.510	2.198	3/16	1/16	.4995	.4990	2.188	2.182
2 1/2	5/8	.626	.625	2.094	2.089	.660	.635	2.733	7/32	1/16	.6245	.6240	2.718	2.712
3	3/4	.751	.750	2.500	2.495	.785	.760	3.265	1/4	3/32	.7495	.7490	3.250	3.244
3 1/2	7/8	.876	.875	3.000	2.995	.910	.885	3.890	5/16	3/32	.8745	.8740	3.875	3.869
4	1	1.001	1.000	3.375	3.370	1.035	1.010	4.390	3/8	3/32	.9995	.9990	4.375	4.369
4 1/2	1 1/8	1.126	1.125	3.813	3.808	1.160	1.135	4.953	7/16	1/8	1.1245	1.1240	4.938	4.932
5	1 1/4	1.251	1.250	4.250	4.245	2.285	2.260	5.515	1/2	1/8	1.2495	1.2490	5.500	5.494

All dimensions in inches.

[1]Note: A difference between the overall Cutter Bore and Keyway "D" and the Arbor and Key dimension "F", of .010 inch for Arbor diameters up to 2 inches, and .015 inch on Arbor diameters larger than 2 inches, is allowed.

Aircraft Lighting Developments

Committee at Chicago Meeting Appoints Subcommittees and Lays Down Test Procedure

A MEETING of the Aircraft Lighting Committee held in Chicago on Dec. 7, to discuss the progress and future activities of the Committee, brought together one of the most representative bodies of men ever assembled for standardization work.

Actual operating experiences indicating the trend which the investigation on landing-lights should follow were recounted by W. S. Smith, of National Air Transport; C. N. Monteith, of Boeing Airplane Co.; and A. E. Larsen, of Pitcairn Aircraft, Inc. Mr. Smith pointed out that landing equipment suitable for operation in the East, where the atmosphere is much less clear than in any other part of the Country, necessarily must differ from landing equipment for use in the western part of the Country.

Many phases of lamp location, angles, visibility and movability were discussed, and the question of desirability of a retractable mounting to enable withdrawal of the lamp from the slipstream when not in use was considered. It was generally agreed that consideration should be given to obtaining as small a lamp as will provide proper illumination, and that, in the research work, at least one of the lamps should be dirigible.

The need for prompt action on the part of the Committee was brought out by Mr. Larsen, who stated that the question of landing-lights is a very serious problem that demands immediate attention.

To facilitate the work of the Com-

(*Concluded on page* 96)

Operation and Maintenance

Recruiting of Mechanics

Subcommittee Report on Desirable Selecting and Training Methods

LACK of enough competent mechanics has handicapped the automobile-repair business from its beginning, and a study was made during the last year by Subcommittee No. 3 of the Operation and Maintenance Committee to formulate recommendations for desirable methods of improving the situation and providing, eventually, an adequate number of competent workmen. As a result, the Subcommittee presented the following report, prepared by F. L. Jacobus in collaboration with T. L. Preble, chairman of the Subcommittee, at the Transportation Meeting held Oct. 18 in Newark, N. J.

Report of Subcommittee No. 3

Most of the more than 300,000 automobile mechanics in the United States today have learned their trade by the trial-and-error method. They have started as helpers and, usually by a hit-or-miss system, have picked up sufficient knowledge of the mechanism of an automobile to be able to make adjustments and repairs. Lack of enough competent mechanics has handicapped the automobile-repair business from the beginning. The situation has grown steadily worse, as the number of cars in use has increased faster than men have been trained for the work. Of those who take up this vocation, 78 per cent have had no previous special training.

At least 100,000 new repairmen are needed each year to replace the losses in the ranks and to care for the increased work. Incompetent labor is expensive, and it is impossible to estimate the amount of money that has been spent in tearing down and putting together parts that were in perfect condition. If a large truck or motorcoach is taken off its run for repairs and is held in the shop one day longer than is necessary, the loss in revenue will often exceed the total repair-bill.

Repairs and overhauling account for about 25 per cent of the costs of operation. Most service executives will agree that it is almost impossible to obtain an adequate number of good, reliable mechanics. No doubt one reason has been that wages for this class of work have not been high enough to attract men who are mentally alert, but such conditions do not exist today in the larger organizations because they are willing to pay very good wages for the right kind of men. Automotive design has become somewhat standardized, and production and sales are highly developed; but service is just now experiencing its greatest growth and offers its greatest opportunity.

Transportation is one of the essentials of human existence. The automobile has, in increasing volume, supplied the need until it is no longer a luxury but a necessity. Without proper methods of servicing and a sufficient supply of trained personnel, the automobile loses its efficiency.

SELECTION OF MECHANICS

The selection of men for training has not had the proper attention. Some service managers will not bother with graduates from training schools because experience has proved that only about one out of five is adapted to the work. There is a tendency to commercialize the automobile school and to operate it on a financial basis rather than on the basis of service to the student in the shop, and the graduates of inferior schools tend to lower the reputation of all other training schools. Without an inborn love of tools and machinery, the prospective mechanic can never hope to progress very far. If he likes machinery, he probably has worked in a factory or machine-shop or has tried to secure a job that requires some kind of mechanical work. As to the necessity for work, some men graduate from a training course and apparently are well fitted for their jobs, but they have no incentive to produce. The best type of man is one who supports a widowed mother, or has brothers and sisters to support, and realizes that he must work.

EXPERIENCE AND CHARACTERISTICS

If a man already has had some automobile experience and wants more, he should be given an opportunity to acquire it. The best preparatory training, aside from that in a service station, is acquired in a good machine-shop where the man learns such things as what a thousandth of an inch means and what its effect may be on the fit of a bearing. Regarding his character and personality, the prospect's references should be thoroughly investigated and all of his previous employers heard from before he is accepted. Every man accepted for training should possess the inherent qualifications of an inspector or service salesman. If he continues his course, he will want to work into one of these positions, in which he will deal directly with the customers. His ambitious desire to improve himself by training is highly commendable and should not be discouraged whether he is accepted or not.

The more education the prospective mechanic has, the more desirable he is, so long as he does not object to wearing overalls and getting his hands soiled. The most desirable age for men who have had no previous automotive experience ranges from 18 to 22 years; but the nature of the man's practical experience should be given due consideration.

A STANDARD COURSE RECOMMENDED

Subcommittee No. 3 of the Operation and Maintenance Committee recommends serious consideration by the Society of the project of developing a standard course of training for mechanics. The objective of such standardization of training courses is to enable those who hire graduates to know more certainly what to expect of them and what further training they need to be useful to their employers.

In 1924, the service division of the National Automobile Chamber of Commerce appointed a special committee to study the situation regarding the training of mechanics. The conclusion reached was that a standard course is desirable. In the report of the committee, a suggested standard course is worked out in detail.[1] If the Society should decide to develop a standard course, we recommend that the course proposed by this committee be used as a guide.

Such a plan would be of no value unless some means were provided for checking either the school or the graduate. All institutions would see the advantage of advertising the course and, unless a careful check were made, the result would be a worse situation than we have at present. We would be as uncertain, or more uncertain, than we are now as to what to expect from

(*Concluded on p. 106*)

[1] A copy of this Suggested Standard Plan for Training Automobile Repairmen in Co-operation with the Industry will be mailed on request. Address, Society of Automotive Engineers, Inc., 29 West 39th Street, New York City.

Production Engineering

Cutting-Oils

Soluble Oils Economical If Cooling Is Chief Function —Some Jobs Need Better Lubrication

PROGRESSIVE development in machine-tool design during the last quarter-century is the result largely of the demand of the automotive industry. This demand has been for more production per man-hour and machine-hour to lower production costs. The machine-tool makers were forced to increase the machine speeds, develop new tool-steels, and make machine operation more nearly automatic.

The higher speeds used in cutting metals produced temperatures that were destructive to the work and the tool. The use of cutting-oils to prevent excessively high temperatures while operating at these high speeds has enabled the manufacturer to reduce his costs substantially. The term "cutting-oil" is a misnomer, as the oil does no actual cutting but is merely an important aid to the cutting-tool. However, oil performs a function sufficiently important to justify research and development to secure the most satisfactory cutting-oils.

Action of a Cutting-Oil

Many theories have been advanced to explain the action of a cutting-oil. None of them is completely satisfactory or has been definitely proved; but one point on which all research workers agree is that the oil acts as a cooling medium. Evidence also points very strongly to the conclusion that the oil acts as a lubricant, and it must be granted that this is true to some extent. The chief contention is concerned with the places at which lubrication actually exists.

A good cutting-oil gives definitely a better finish than a poor one. Probably the oil provides lubrication between the part of the work that has just been passed over and the part of the tool immediately back of the cutting edge. This would give a burnishing effect, resulting in a better finish.

The question as to lubrication between the chip and the tool is very debatable. It seems impossible that the oil could creep between the tool and the chip against the pressure and the counterflow of metal that it meets. Yet a cutting-oil aids in preventing spalling and gouging of the tool. There have been many learned discussions on surface tension, oiliness, and facial concentration of cutting-oils of various types. Such arguments are of little interest to the production man who secures his ideas from a study of actual performance. It is sufficient to state that certain oils give better results than others and to leave the investigations to the laboratories.

Different Types of Cutting-Oil

Oils that first served as other than cooling mediums were animal and vegetable oils. Some years ago they were commonly used in the pure state, and it seemed that this was necessary. They were expensive and, therefore, wideawake purchasing agents eyed them with disfavor. The fatty or "fixed" oils had other drawbacks also, because of their origin and inherent characteristics. Consequently, investigations soon were instituted to find substitutes for these expensive products, and developed the fact that it was not necessary to use 100 per cent of fixed oils, but that virtually the same results could be secured by compounding them with mineral oils. Eventually, the users of cutting-oils found that 20 or 30 per cent of the fixed oil was all that was necessary, and for many operations the concentration could be made still lower. A number of such combinations are used today and are given the general name of mineral-lard oils. They have their advantages and disadvantages, their protagonists and antagonists, but seem to have been losing their position during recent years, owing partly to their cost and partly to the endeavors of the oil manufacturers.

The success secured with the use of cutting-oils having a reduced compounding content encouraged investigators to try other materials. It was found that if sulphur was combined chemically with the fixed oils it increased their efficiency. This resulted in the bringing out of products now known as base oils. These are black, viscous materials that are unsuitable for use in their original state. A mixture of one of these base oils and a cheap parafin oil makes a fairly satisfactory cutting-oil, and such mixtures are in rather common use today. Some of the prepared cutting-oils now on the market are mixtures of this type. The manufacturer who buys a base oil and makes his own cutting-oil can vary the concentration to suit the operation. This scheme is subject to the difficulty that careless mixing may cause undesirable variations.

In the cutting-oil industry, as well as in other industries, new materials are being tried constantly in an endeavor to secure a cure for all ills. Weird chemical materials and compounds of may varieties have been added to mineral oils to improve their qualities as cutting-oils. It is needless to analyze these mixtures; it will suffice to state that their successes have not been such that they have displaced other oils to any great extent. The expense of their manufacture and the unforeseen difficulties they developed have caused most of them to be discarded.

The most recent improvement of cutting-oils has been the addition of sulphur to mineral oils. This addition seems to give the mineral oil an action more nearly like that of fixed oils. The sulphurized oils are very satisfactory for the great majority of operations and are desirable from a cost viewpoint. Their use has become widespread during the last few years and promises to become more general in the near future.

Several methods are used by various oil manufacturers in combining sulphur with the oil. The indications are that the higher the sulphur content is, the more efficient is the oil; and this has led to a gradual increase of the percentage of sulphur. How far the manufacturers will be able to carry this increase is uncertain, but probably the limit has nearly been reached. This may not be unfortunate, as it is likely to be discovered that it is unnecessary to go above a certain point, as in the case of mineral-lard oils.

Strange as it may seem, sulphur only in certain forms is beneficial. Natural sulphur remaining in the oil after refining seems to have little effect. Oils containing sulphur that has been combined with certain fractions in the oil have given the most satisfaction. The chief objection to oil of this type is the black color given to it by the addition of the sulphur. Undoubtedly, this will be overcome by someone and the objection removed.

Soluble Oils

In a discussion of cutting-oils it would be a serious error to omit soluble oils. The gallonage of soluble oils marketed is not as large as that of cutting-oils, but the amount of cutting mixture made from the soluble oil is tremendous. Concentrations varying from 1 part of oil to 10 parts of water to 1 part of oil to 100 parts of water

are in use in different shops. Probably the average proportion is 1 part of oil to about 30 parts of water.

Soluble-oil mixtures are attractive to large users because of their cooling action and low cost. It must be realized that the lubrication given by a soluble-oil mixture is slight, and that the chief benefit is derived from its cooling action. Water, used alone, would cause rusting of the work and the machine and great replacement expense. Accordingly, soluble oil has an extensive and growing use in the shop.

The question of where soluble oil properly can be used has caused much discussion. Some favor it in every possible place, because of its low cost. Others fear to use it in complicated machines in which danger exists of a lack of lubrication of the working parts. This is a question for the users to decide, and thus far the decisions vary widely. A good soluble oil that will mix readily, make a permanent emulsion, protect the finished work and the machine from rusting, and maintain its original state, has many possibilities.

Choosing the Proper Oil

Choice of the most suitable oil for a certain operation or for a number of operations is not difficult. There are only two variables in a cutting-oil: viscosity and compounding. For some operations the viscosity of the oil used is of little effect, whereas for others the best economy depends almost entirely upon the body of the oil. Generally, the viscosity should be kept as low as possible because of the ability of the lighter oils to circulate more freely for heat dissipation.

For slow-moving machines such as broaches, a heavier oil is needed, because it is necessary to carry the oil into the work. In high-speed deep-drilling, lubrication between the side of the hole and the drill is definitely needed, and to satisfy this need an oil of sufficient viscosity must be provided. With soluble oil, the temperature can be kept sufficiently low so that lubrication is not so essential.

To recommend a certain type of oil for the compounding chosen could only precipitate an argument. The user should secure an oil that gives service compatible with its cost. Very likely the oil he chooses will not be the one in use at his neighbor's shop, yet both may give good results.

While there are only two chief variables in cutting-oil, there may be more than a dozen variable factors in one machining operation. The tool and the material, the speed, feed and setup, the condition of the machine, and the like, can be varied; and a change in any of these is sufficient to make a cutting-oil seem good or bad. The most important variable of all is the operator. Human nature is influenced by environment and by any incident that occurs within vision; hence an operator's ideas about a cutting-oil are not always unbiased.

The only reasonable way to decide on the proper cutting-oil is to run tests on various oils for a time and judge them by their all-round performance. Too often an oil is rejected or accepted on the basis of one short test which may not be a true indication of its value. Often it is difficult to choose between two oils, but eventually the difference will become apparent, perhaps on another type of work. Use of the most suitable oil may save time for men and machines, allow an increase of machine-speed, give longer tool-life and have a lower consumption than other oils. All of these factors mean the saving of money which in the long run, will more than balance the higher cost of the oil.—J. C. Sharp, lubricating engineer, Standard Oil Co. of Indiana.

Is Cutting-Oil a Lubricant?

WHEN metal is disrupted by physical means, interatomic energy is liberated as heat. This is what happens when metal is cut in the machine-shop. Metal-cutting is essentially a shearing action, and as the metal is torn apart at the point of a tool the atoms constituting the metal are separated and the energy which is holding the atoms together is liberated. Unless this heat is removed rapidly from the source of generation, the cutting-tool and the metal being cut will become inordinately hot, the work jagged and torn, and the tool will be damaged.

The problem is to remove as much heat as possible in the shortest possible time. Water has a very high specific heat and is used extensively for absorbing heat, in quenching; but its comparatively low boiling-point militates against its general usefulness as a coolant in metal-cutting operations. For this and other reasons, oils are employed. These have the advantage of higher boiling-points and also have greater wetting action.

It seems almost inconceivable that some scientists should advocate the use of a lubricant in metal-cutting. The function of a lubricant is to prevent friction, and friction is essential to metal-cutting, for friction can be prevented only by separating two bodies and, if the tool be separated from the metal that it is to cut, there can be no cutting.

It is not suggested that there is no heat from friction in metal-cutting, for it is self-evident that, after the metal has parted at the point of the tool, it must pass over the surface of the tool. In this respect alone the use of a lubricant is beneficial.

Sulphur-impregnated mineral oil is a product of the last 10 years and has marked one of the most signal advances in scientific metal-cutting. Sulphonated oils not only satisfy the demands of theory, as presented by authoritative scientists; they are the most efficient oils in practice. They are compounded and manufactured on the theory that metal-cutting is essentially a shearing operation and that the heat liberated is intermolecular heat and that the heat of friction plays only a secondary and very insignificant part.

Sulphur has very great refrigerating properties and, when introduced by chemical combination into certain oils, materially increases their thermal conductivity and helps them to conduct heat away from the tool and the metal. Sulphonated oils also increase the wetting action of water and allow it to come into close proximity to the cutting edge.—Houghton's *Black and White*.

Production Papers in This Issue

TWO Production Meeting papers and discussion on a third are printed in this issue of the S.A.E. JOURNAL. The discussion is on W. W. Nichols' paper on Power-Transmission Engineering as an Economy, which was printed in THE JOURNAL for December, beginning on p. 557.

Since the losses due to wasteful power-transmission have been recognized for many years, papers and discussions on this subject might be supposed to be ancient history. That the subject is still a very live one is indicated by the hearty endorsement of this paper by men who know the conditions as they are today and by reports of great savings, in one instance amounting to $1000 per day in a single factory, that are being made in large automotive factories by the employment of methods such as those advocated by Mr. Nichols.

Selection of Conveyor Power-Units is the subject of a paper by C. E. Broome, which will be very helpful to everyone who has to do with this problem. To an almost unbelievable degree Mr. Broome has made the selection of such a unit an exact engineering problem, rather than something to be determined by the persuasive powers of a salesman.

The paper on Gear-Tooth Breakage, Wear and Noise, by A. B. Cox, treats of the excellent results claimed from gears proportioned so that two pairs of teeth are in contact at all times. This paper was given a place in the Production Meeting because quietness of gears generally is regarded as a production problem. The solution offered, however, is one of design rather than of production.

Annual Meeting Program Complete

Wide Range of Interest Covered by the Numerous Papers—A Feature Session Scheduled for Each Evening

ANY member of the Society who attempts to attend *all* the technical sessions at the Annual Meeting, Jan. 15 to 18, at the Book-Cadillac, and also the technical, professional and administrative committee meetings scheduled, will find that he has assumed an impossible task. Many of the sessions and meetings are to be held simultaneously, and the wide range of subjects to be covered would require wearying concentration to absorb the volume of technical information which will be presented.

Although the Annual Meeting starts officially on Tuesday, Jan. 15, several committee meetings will be held on Monday. Tuesday morning also will be devoted to committee meetings. The Annual Meeting proper will start with the Research Session, at the close of which the Annual Business Meeting has been scheduled.

Popular Subject at Night Session

The Annual Meeting Committee has recognized that, in view of the large attendance that can be expected, the evening sessions should be devoted to subjects having the broadest possible appeal. The subject having perhaps the greatest general interest of any scheduled for the Annual Meeting is the Economic Requirements of Automotive Road-Vehicles Abroad, which is to be presented by J. D. Mooney, president of the General Motors Export Co., at the Tuesday evening session. This paper, which will be available in complete form shortly before the meeting, outlines the economic requirements that automotive-vehicle designers must meet if they are to compete successfully in foreign markets. Mr. Mooney does not attempt to indicate what type of vehicle must be designed; this is for the automotive engineer to decide. He merely correlates the experience of the General Motors Export Co. and presents it in such a form that the automotive designer, when making his decisions, will have definite knowledge of the economic conditions which the design must meet.

Mr. Mooney's paper will be presented by title only, the actual presentation being an informal discussion of the more important points brought out in the paper, with sidelights thereon. This will be followed by a general discussion and by a motion picture entitled The World Builds a Motor Car, which has been prepared by the General Motors Export Corp. to aid in the promotion of American automotive transportation in foreign countries. This picture illustrates many of the points emphasized by Mr. Mooney and will give the members an opportunity to visualize conditions as they exist in the far corners of the earth.

J. D. Mooney

The Presidential Address will be delivered by Col. W. G. Wall at the same session. Chairman J. A. C. Warner, of the Society Meetings Committee, will preside.

Body Dinner and Session

The Wednesday evening session is being sponsored by the Detroit Section Body Division. A Body Division Dinner, for which Detroit is now famous, will precede the technical session, an interesting entertainment having been promised for this dinner. Reservation blanks for the dinner are, at the time of going to press, being prepared for mailing. The session, at which Chairman W. N. Davis, of the Detroit Body Division, is to preside, will be addressed by President-Elect W. R. Strickland and by O. T. Kreusser, of the General Motors Proving Ground, who will review the 1929 automobiles from the purchaser's viewpoint. Mr. Kreusser needs no introduction, having addressed the Detroit Section last year regarding what the abstract customer likes or dislikes in the motor-car.

Laboratory Inspection Session

An unusual feature of an Annual Meeting is the Thursday evening session, which will be held at the Chrysler Engineering Laboratory on Massachusetts Avenue. The speakers include W. L. Mitchell, vice-president of the corporation in charge of all operations, F. M. Zeder, vice-president in charge of engineering, and W. P. Chrysler, president. Motion pictures and an inspection of the various laboratories will follow the technical program.

The Meetings Committee has scheduled nothing for Friday evening, so that the members who wish to do so may attend the Annual Automotive Carnival at Oriole Terrace.

Much for Engine Designers

With reference to the morning and afternoon sessions scheduled for each of the four days of the meeting, the Committee has endeavored to schedule discussions of many of the outstanding problems of the day. The program will be specially attractive to engineers interested in engine design. In addition to the Engine Research Session on Thursday morning and the two Engine Sessions on Friday, the Research and the Transmission Sessions on Tuesday and Wednesday will have much of value to engine designers.

It is logical that the Annual Meeting should give prominence to engine subjects, as engine design and performance are of interest to all members of the Society.

Members who wish to take part in the discussions should obtain copies of the available abstracts and preprints of the papers in advance of the meeting. A return form for requesting these will be found on p. 14 of the advertising section of this issue.

The Annual Meeting program containing the names of all who are to present prepared discussion, will appear in a special *Meetings Bulletin* to be issued early in January. The Meetings Committee has also been able to arrange, through the courtesy of the *Automotive Daily News*, for the issuance of a daily announcement preceding each of the four days of the meeting.

The railroads are granting reduced fares for the meeting; therefore members should ask for reduced-fare certificates when purchasing tickets.

Annual Meeting Program

Book-Cadillac, Detroit, Jan. 14-18

Tuesday, Jan. 15

9:30 A. M.—STANDARDS COMMITTEE MEETING

H. M. Crane, *Chairman*

1:30 P. M.—RESEARCH SESSION

H. L. Horning, *Chairman*

Vapor-Pressure Data on Motor Gasoline—Dr. O. C. Bridgeman, Bureau of Standards.

Economic Fuel Volatility and Engine Acceleration—Donald B. Brooks, Bureau of Standards.

Operating Factors in Engine Acceleration—Donald B. Brooks, Bureau of Standards.

Results to Date in Headlight Research—H. H. Allen, S.A.E. Research Subcommittee on Headlighting.

4 P. M.—SOCIETY BUSINESS MEETING

President W. G. Wall, *Presiding*

Reports of Administrative Committees
Report of Treasurer
Reports of Technical Committees
} To be presented by title only.

Nomination and Election of Members-at-Large of Nominating Committee.

Report of Society Reorganization Committee—F. E. Moskovics, *Chairman.*

8 P. M.—FOREIGN AUTOMOTIVE TRANSPORTATION SESSION

J. A. C. Warner, *Chairman.*

Presidential Address—Colonel William Guy Wall.

Economic Requirements of Automotive Road Vehicles Abroad—J. D. Mooney, President, General Motors Export Co., and Clarence M. Foss, Engineer, General Motors Staff.

The World Builds a Motor Car—A Motion Picture.

Wednesday, Jan. 16

10 A. M.—TRANSMISSION SESSION

S. O. White, *Chairman*

Axle Ratios and Transmission Steps—Carl D. Peterson, Engineer, Durant Motors, Inc.

Prepared Discussion by C. A. Neracher, Consulting Engineer; H. E. Blood and J. G. Monjar, Detroit Gear & Machine Co.; Floyd A. Firestone, University of Michigan; H. M. Crane, Technical Assistant to the President, General Motors Corp.; E. S. Marks, Chief Engineer, H. H. Franklin Mfg. Co.

2 P. M.—FUELS AND LUBRICANTS SESSION

G. A. Round, *Chairman*

Importance and Significance of Gum in Gasoline—J. O. Eisinger, Research Engineer, and Vanderveer Voorhees, Standard Oil Co. of Indiana.

Some Thoughts on Detonation Measurements—J. P. Stewart, Engineer, Vacuum Oil Co.

Fluidity of Lubricating Oils—E. R. Lederer and F. R. Staley, Texas Pacific Coal & Oil Co.

Better Chassis Lubricants—C. W. Spicer, Chief Engineer, Spicer Mfg. Corp.

2:30 P. M.—BODY SESSION

(Sponsored by the Detroit Section Body Division.)

C. B. Parsons, *Chairman*

Body Ventilation in Conjunction with Heating—William Lintern, President, Nichols Lintern Co.

Causes and Methods of Elimination of Vibration and Rumble—H. W. Stewart, District Manager, Emulsion Division, Republic Paint & Varnish Works.

The Color Analyzer—Dr. A. C. Hardy, Massachusetts Institute of Technology and General Electric Co.

6:30 P. M.—DETROIT SECTION BODY DIVISION DINNER AND ENTERTAINMENT

8 P. M.—BODY SESSION

(Sponsored by the Detroit Section Body Division.)

W. N. Davis, *Chairman*

Address by President-Elect W. R. Strickland.

Mr. Abstract Returns and Reviews the 1929 Cars—O. T. Kreusser, Manager, General Motors Proving Ground.

Thursday, Jan. 17

10 A. M.—ENGINE-RESEARCH SESSION

Alex Taub, *Chairman*

The Electric Telemeter and Valve-Spring Surge—W. T. Donkin and H. H. Clark, Engineers, Cleveland Wire Spring Co.

Idiosyncrasies of Valve Mechanisms and Their Causes—Ferdinand Jehle, Research Engineer, and W. R. Spiller, Laboratory Engineer, White Motor Co. Prepared Discussion by W. A. Scholey, Cook Spring Co.; E. W. Stewart, William D. Gibson Co.; C. P. Nelson, L. A. Young Industries, Inc.

Interpretation of Indicator Cards—Robert Janeway, Consulting Engineer. Prepared Discussion by C. Fayette Taylor, Massachusetts Institute of Technology.

The DeJuhasz Indicator—K. J. DeJuhasz, Pennsylvania State College.

2 P. M.—CHASSIS SESSION

Earle Gunn, *Chairman*

Aspects of Motor-Car Engineering Associated with Balloon Tires—J. G. Vincent, Vice-President in Charge of Engineering, and W. R. Griswold, Engineer, Packard Motor Car Co. Prepared Discussion by H. A. Huebotter, Butler Mfg. Co.

Notes on Frame and Body Road-Vibrations—F. F. Kishline, Experimental Engineer, Graham-Paige Motors Corp. Prepared Discussion by W. C. Keys, U. S. Rubber Co.

Testing of Brake-Lining for Uniformity in Production—W. S. James, Research Engineer, Studebaker Corp. of America.

Progress Report of Research Subcommittee on Front-Wheel Alignment—J. M. Nickelsen, University of Michigan.

8 P. M.—CHRYSLER ENGINEERING LABORATORY SESSION

(At the Chrysler Plant)

W. L. Mitchell, *Chairman*

Addresses by Fred M. Zeder, Vice-President in Charge of Engineering, and Walter P. Chrysler, President.

Motion Pictures and Inspection of the Laboratory.

Friday, Jan. 18

10 A. M.—ENGINE SESSION

O. C. Berry, *Chairman*

Ignition Requirements for High-Compression Engines—J. T. Fitzsimmons, Engineer, Delco-Remy Corp.

Dual Carbureters and Manifolds—F. C. Mock, Research Engineer, Stromberg Motor Devices Co.

The Economic Situation with Regard to Antiknock Fuels—L. C. Lichty, Assistant Professor, Yale University.

2 P. M.—ENGINE SESSION

L. P. Kalb, *Chairman*

Effect of Humidity on Engine Performance—A. W. Gardiner, Research Engineer, General Motors Corp. Research Laboratories. Prepared Discussion by N. S. Diamant, Consulting Engineer, Chrysler Corp.

Engine Bore-and-Stroke Ratios—Alex Taub, Development Engineer, Chevrolet Motor Co.

Failure of Connecting-Rod Bearings—D. E. Anderson, Bohn Aluminum & Brass Corp.

8 P. M.—PRODUCTION SESSION

John Younger, *Chairman*

Recent Developments in Chromium-Plating—M. F. Macaulay, Engineer, Oakland Motor Car Co., and W. M. Phillips, General Motors Corp. Research Laboratories.

Steels for the Automotive Industry—T. McLean Jasper, Director of Research, A. O. Smith Corp.

Recent Developments in Production Grinding—B. H. Work, Assistant Chief Engineer, The Carborundum Co.

The Jewels of Industry—A Motion Picture.

Temple High-Velocity Penetration Devices—Robert Temple.

The 1928 Aeronautic Meeting

(*Continued from p. 12*)

use them for vertical thrust as well as longitudinal forward and reverse thrust. Exhaust condensers, to recover water from combustion and compensate for reduction of weight by consumption of liquid fuel, have proved successful, and, to reduce the parasitic drag of the coolers, these are arranged along the surface of the hull. The proposed system also has a counterflow pre-cooler which takes the exhaust gases directly from the engines and reduces the temperature about 80 per cent. Air used as a cooling medium is piped to the control car and passenger cabins for heating. Soot collectors are interposed between the pre-cooler and the condensers.

All passenger accommodations can be built inside the hull, when helium is used for lifting, thus increasing the aerodynamic efficiency of the ship.

Dr. Arnstein brought his paper to a conclusion with mention of the new rigid airships under construction in England and descriptions of the two small non-rigid ships, the Pilgrim and the Puritan, which are forerunners of larger ships of this type now under construction by the Goodyear-Zeppelin Corp.

Foreign Delegates Come In

At this stage in the proceedings a small stir was created by the entry of a group at the rear of the room, and Chairman Seymour called upon Secretary Warner, who, in the course of a few brief remarks, stated that the meeting had visitors from some of the foreign countries in which interest in airships also runs high. Among them, he said, was Lord Thomson, former Air Minister of Great Britain, to whom probably more than anyone else is due the inauguration of the present British airship program that is likely to bear fruit shortly in renewed Atlantic crossings by lighter-than-air craft under the British flag. These delegates to the International Civil Aviation Congress, held in Washington the following week, had been invited by Mr. Warner to come in for the closing stage of the S.A.E. program.

New Moving Means Developed

Commander Rosendahl's address was replete with interest, as it told of the most recent developments of means for mooring and housing buoyant airships. Foremost among these are a stub mooring-mast, a so-called semi-portable or quickly erected mast for outlying use, a floating type of mast such as has been installed on the airship-tender Patoka, and a holding-down stern-carriage rolling on a circular track encircling the stub mooring-mast.

The stub-mast and stern-carriage equipment was described as consisting of a mast 60 ft. high to which the nose of the airship is secured and which is hinged at the foot so that it can be lowered. In the base of the mast are provided servicing facilities, such as electricity, fuel, water and helium, for the ship.

To restrict any tendency of the stern to vertical motion and to allow horizontal rotation around the mast with veering of the wind, a circular standard-gage railway was built around the mast and a holding-down carriage of steel was fitted to the rails by rollers that prevent it being lifted from the track. The Navy now has developed suitable means for attaching the after-car of the Los Angeles to this carriage so that the stern of the ship will be automatically disconnected when the airship is freed from the mast at the forward end. Further refinements in both the mast and the track are anticipated.

A Mobile Mast Being Built

The next phase involved in equipment for taking care of an airship at its destination is that of moving it safely across the field to and from and into and out of the hangar. By making the stub mast mobile, the Navy will provide the principal unit of equipment for moving the ship on the ground largely by mechanical means, said Commander Rosendahl. At Lakehurst, N. J., such a mast is now under construction. It is a three-legged steel structure on a triangular base mounted on three truss wheels so that it can be towed. The upper portion of the mast is telescopic and the base contains facilities for ballasting and servicing the ship during its progress across the field or in or out of the hangar if necessary. For holding the ship against side winds, an endless wire bridle running from reinforced parts of the ship to trolleys running in rails parallel to the axis of the hangar will be provided.

In conclusion, Commander Rosendahl said that many communities have expressed a desire to erect mooring-masts and provide servicing facilities for airships, but advised awaiting further trial of the experimental equipment now in hand at Lakehurst. As soon as the engineers there are satisfied that such equipment is suitable for general use, they will gladly tell everyone interested. It now looks, he said, as if the United States will be first to solve the mooring and handling problems, and this, together with our natural helium monopoly, should make this Country independent of the rest of the world and put it in first place in airship transportation.

Airplane-Propeller Design

In the final paper of the meeting Lieutenant Havill discussed at length the design of airplane propellers, as developed by the Army and the Navy, and the gearing of propellers. This paper is printed in full in this issue of the S.A.E. Journal, beginning on p. 17.

Owing to the great amount of information given in the several papers and the length of time required to present them, virtually no time was afforded for their discussion, although the meeting was not declared finally adjourned until 11 p.m.

Aero Show in Three Buildings

Great Variety Characterizes Huge Display of Airplanes in Chicago's Coliseum and Armory

How greatly the aeronautic industry has developed during the last few years was impressively shown by the International Aeronautical Exposition held by the Aeronautical Chamber of Commerce of America from Dec. 1 to 9 in the Coliseum, the Greer Building and the First Regiment Armory, Chicago. The main floor in all three buildings was completely filled with airplanes and displays of engines, while the balcony in the Coliseum was equally filled with displays of aircraft accessories. The thousands who daily attended the exhibition amply attested the fact that aviation has caught the public imagination. This was the second aeronautic exposition this season, the first having been held at Los Angeles last September; and a third is being promoted, to be held in New York City early in the

new year. In this and other obvious respects the aeronautic industry is going through much the same stages of development as the bicycle and, later, the automobile industries passed through in arriving at stabilization and standardization of types three decades and two decades ago respectively.

Variety Most Noticeable

Diversity of design was the most noticeable characteristic of the exposition to anyone who was able to detach himself from consideration of details long enough to think of the huge display as a whole. In this respect it could not fail to recall vividly to veterans in the automobile industry the automobile shows held in the same buildings during the first decade of the 20th century, when there was little or no uniformity in chassis, engine or body design and everyone was trying to forecast the probable trend, with fortunes awaiting the lucky guessers.

So, in the aeronautic exposition, almost no two makes of airplane were alike. The 70 complete aircraft were almost equally divided between biplane and monoplane, and between open and cabin types. Of the 34 biplanes, 27 had open cockpits and 7 were cabin craft. Of the 31 monoplanes, the order was reversed, 11 having open cockpits while 20 were cabin craft. Land craft vastly predominated, but amphibians were represented by four examples, a Loening cabin biplane fitted with the only three-bladed propeller observed in the show; a Sikorsky twin-engined cabin amphibian, a Boeing pusher biplane, and a Fokker six-to-eight-passenger single-engined pusher monoplane, with the engine mounted high above the wing and the wing on top of the cabin-hull.

The International Aircraft Exposition at the Coliseum

Designers clearly are not only divided in opinion between the merits of the monoplane and the biplane, but each major division has diverse views regarding arrangement of the wings, the disposition of the pilot and passengers, if any, and numerous other details. Thus, in the monoplanes, the small open models had the cockpit above the wings in most cases, whereas the giant passenger-models had the wings above the cabin.

In size the exhibits ranged from a motorless All-American glider, that attracted a great deal of popular attention, to two enormous Ford all-metal passenger monoplanes and a Keystone twin-engined Army biplane mounting two Lewis machine-guns. In the Armory was the skeleton duralumin framework of a gigantic Martin biplane exhibited by the Great Lakes Aircraft Co. Also in the Armory was shown the smallest power-driven plane, a Heath Super-Parasol monoplane fitted with a little four-cylinder in-line air-cooled engine. Another diminutive model was the Flying Dutchman open monoplane, shown both in skeleton and covered, by the Szekely Aircraft Corp. in the Coliseum. Not so small and yet not so large was the famous de Havilland Gypsy Moth, two-seater biplane fitted with slotted folding wings.

The public seems a long way from having come to any conclusion regarding airplanes, beyond the certain fact that it is interested. Whether it is going to get its flying experience first as passengers on air-transport lines or through private ownership and operation remains to be determined; it seems probable that it will be in both ways. Visitors at the show seemed about equally interested in all models; they went to learn and examined everything.

Another General View of the Coliseum from the Opposite End

Business and Transport Planes

For certain individual reasons a few of the displays attracted special attention. One of these was the Vought Corsair biplane owned by Admiral William A. Moffett and used by him as a "flying office," although the office was not evident, as it was an open two-seater of the high-speed, high-performance type with no space for office equipment.

A unique display that offered business men a concrete hint of the possible commercial applications of the airplane was the tri-motored 12-passenger Ford monoplane fitted up as the Independence Grocery Store. The whole of the large cabin was provided with spe-

cial metal shelving on which were arranged an elaborate display of more than 200 different canned goods in tins and glass jars. This had been flown to the show just as it was fitted up and during the coming year is to be flown to all important cities in the Country as an exhibit of the Reid, Murdock & Co. food products.

A companion Ford display was the City of Columbus 14-passenger trimotored plane which is to be used with others of the same model by the Transcontinental Air Transport in the coast-to-coast combination airplane-and-train passenger service for the early inauguration of which all arrangements are now being made.

Very appropriately with the arrival of real winter weather on Tuesday night of show week, the Mercury Aircraft Corp. showed a two-passenger cabin monoplane fitted with ski attachments for the landing wheels. In the Hamilton and Chance Vought spaces were shown large detachable floats for converting a land plane into a seaplane.

One trend that is very definite is that in engines. All of the new craft were powered with air-cooled engines, and, with the exception of three or four models, all were of the radial non-rotating type using gasoline as fuel. Here the uniformity ceased, however, for the engines seen included three, five, seven, nine and twelve-cylinder air-cooled radials. In addition, one or two examples were noted of in-line and V-type air-cooled engines. Eighteen aircraft-engine companies had exhibits, all on the main floor of the Coliseum.

In the balcony of the Coliseum and in the north balcony and south hall ballroom were the displays of more than 100 suppliers of aircraft accessories, including materials, parts and fittings, tires, bearings, instruments, propellers, lamps, generators, magnetos, oils, and aeronautical periodicals.

Associations and services represented included a fully equipped branch of the United States Post Office, which did a lively business all week long in the dispatching of air-mail letters; the Department of Commerce, the Society of Automotive Engineers, the Aeronautical Chamber of Commerce, the American Air Transport Association, the Chicago traffic Association, and the Grey Goose Air Lines.

Standardization Activities

(*Concluded from p.* 88)

mittee, L. E. Lighton, E. A. Robertson and D. S. Cole were appointed a Subcommittee to work out the details of electrical installation for the test and to cooperate with the engineers of the six operating companies which have agreed to the installation of lighting equipment on their airplanes for the collection of data. A Lamp Subcommittee also was appointed, consisting of W. M. Johnson and L. C. Porter, to handle the question involving the lamp bulb.

A third Subcommittee, consisting of E. A. Sipp and J. D. Peace, Jr., was appointed to arrive at satisfactory lamp dimensions in cooperation with the engineers of the testing companies.

Test Procedure Laid Down

The following test procedure was tentatively laid down:

(1) *Beam Spread.*—Each operator to be supplied with a reflector of minimum spread. Lens equipment is to be provided which will allow spreads up to 40 deg., each operator to study the light effects of two kinds; that is, the pick-up or pencil beam and the landing or diffused beam.

(2) For the experimental test all lamps are to be of the same structure but mounting is to be left to the judgment of the operators who will mount them.

(3) An effort is to be made to determine the minimum intensity necessary for these two types of beam.

(4) These data will be presented to the Committee in an attempt to determine methods for achieving the necessary desired results.

A preliminary data-sheet and uniform method of recording results will be prepared by a Committee consisting of Messrs. Johnson, Smith and Cole.

The following representatives were present at the meeting:

W. M. Johnson, *Chairman*, National Lamp Works
C. B. Chupp, Pitcairn Aircraft, Inc.
D. S. Cole, Leece-Neville Co.
Arthur F. Haeger, Bryant Electric Co.
A. E. Larson, Pitcairn Aircraft, Inc.
L. E. Lighton, Electric Storage Battery Co.
A. L. Martinek, Ford Motor Co.
Crawford McGinnis, Pyle-National Co.
C. N. Monteith, Boeing Airplane Co.
W. C. Naylor, William B. Stout Aircraft Engineering Co.
J. D. Peace, Jr., Pioneer Instrument Co.
E. A. Robertson, Rome Wire Co.
E. A. Sipp, Pyle-National Co.
W. L. Smith, National Air Transport, Inc.
A. J. Underwood, S.A.E. Standards Department
W. D. Williams, National Air Transport, Inc.
Wm. A. Wulee, Pyle-National Co.

To Review Spline Standard

For some time the Transmission Division of the S.A.E. Standards Committee has been studying the desirability of including the specifications for side-bearing splines in the present S.A.E. Standard. This has been restricted to 10-key splines, as this is the type of spline in most general use, but the study may be extended to the other spline so as to have the standard reasonably complete.

At a meeting of the Division in Detroit recently, C. W. Spicer, of the Spicer Mfg. Corp., and M. B. Morgan, of the Timken-Detroit Axle Co., with P. L. Tenney, of the Muncie Products Division of the General Motors Corp. as Chairman, were appointed by Division Chairman White to formulate a report to the Division. An important part of this work includes the preparing of descriptive or explanatory paragraphs for inclusion in the standard regarding its applications and limitations. The report of the Subdivision when prepared will be published in the S.A.E. Journal before it is finally passed upon by the Transmission Division of the Society for adoption.

Transmission-Oil Viscosity

At the Lubricants Division meeting held on June 7, 1928, a revision of the present Transmission-Oil Viscosity Numbers, p. 470 of the 1928 edition of the S.A.E. Handbook, was proposed, with the suggestion that such a revision include the viscosity ranges with corresponding S. A. E. numbers only, as in the case of the Crankcase Lubricating-Oil Viscosity Numbers, omitting all other qualities from consideration.

The report, which provided for four grades of transmission oil with proposed viscosity values given both in Saybolt and Furol terms at 100 deg. fahr. temperature, was submitted for criticism to a Subcommittee of Committee D-2, of the American Society for Testing Materials. The report of this Subcommittee was unfavorable to the proposal, and, to obtain further discussion, a joint meeting of the Lubricants Division of the S.A.E. Standards Committee and Committee D-2 of the A.S. T.M. was held in Chicago on Dec. 3.

Considerable difference of opinion was expressed as to the value of a viscosity numbering system for transmission oils, but the majority opinion seemed to be that such a system would prove as valuable as had the viscosity numbers for crankcase lubricating-oils. However, in the absence of any specific revisions to the original Lubricants Division proposal, it was considered advisable to request Subcommittee D-2 to meet further with the Lubricants Division to work out a new series of viscosity numbers and Saybolt or Furol values.

The Lubricants Division then adjourned to consider the question of S.A.E. Viscosity Numbers for Crankcase Lubricating-Oils as applied to prediluted oils. Its report will be found under Standards Committee Division Reports elsewhere in this issue.

Motorcoach Whys and Wherefores

A. E. R. A. and S. A. E. Metropolitan Sections Consider Present Design Trends and Operation Methods

THE joint meeting of the Metropolitan Sections of the Society and of the American Electric Railway Association held Dec. 7 in New York City was an eventful occasion for engineers of both organizations who are specifically interested in motorcoach design, operation and maintenance. The dinner at the Park Central Hotel was attended by 194 members and guests and was presided over by Chairman S. R. Dresser, of the S.A.E. Metropolitan Section. Afterward, motorcoaches transferred those in attendance to the Engineering Societies Building, where it was found that many other engineers had already assembled to attend the technical session. When Chairman A. L. Hodges, of the American Electric Railway Association, called this session to order, nearly 350 were present.

Following a brief business session of the A.E.R.A., Mr. Dresser assumed the chair and explained the reorganization chart of the Society which is now under consideration, a copy of which was included in the December issue of the S.A.E. JOURNAL, and asked that members of the Society consider this reorganization plan carefully and send their comments to the Society's office.

Mr. Dresser also remarked upon the hearty cooperation of the two Societies, as evidenced by this joint meeting, and said that other cooperative meetings of this kind undoubtedly would broaden the scope and accomplishments of both. After welcoming the A.E.R.A. members who were present and inviting them to attend future meetings of the S.A.E. Metropolitan Section, he introduced William H. Sawyer, of the A.E.R.A., who assumed the chairmanship and styled this a We, Us & Co. meeting which he hoped was the forerunner of similar gatherings.

The subjects and speakers were as follows: Modern Motorcoach Design that Meets the Demand of Uptodate Transportation Needs, by George A. Green, of the Yellow Truck & Coach Mfg. Co.; Profitable Motorcoach Operation That Fits the Motorcoach to the Transportation Needs, by R. M. Graham, of the Pennsylvania-Ohio Edison Co.; and Practical Motorcoach Maintenance, including factors and systems that constitute efficient service, by Adrian Hughes, Jr., of the United Railways & Electric Co. of Baltimore. These papers were so replete with carefully thought-out discussion of present practice and future trends that the speakers held the interest of the audience throughout the entire time allotted to the session; therefore no time was afforded for general discussion.

UPTODATE MOTORCOACH-DESIGN

Discussing the issue from an engineering viewpoint, Mr. Green said in part that the motorcoach industry is in its swaddling clothes. Twenty years ago horse-drawn stages were operated on Fifth Avenue, and at about that time the first gasoline-propelled vehicle appeared. In the speaker's opinion, to say that we have progressed rapidly in this kind of motor-vehicle development would not be a fact. The lack of progress is due largely to lack of foresight on the part of both the manufacturers and the possible buyers; that is, electric-railway and the steam-railroad operators. At first, none of these corporations could visualize the great future of the motorcoach. While this condition has been changed and is very different at present, much valuable time has been lost needlessly.

Mr. Green divided motorcoach equipment into three types. The first group, comprising small vehicles which seat from 8 to 16 passengers, are built from conventional automobile parts and are sold largely for use in connection with schools and hotels. The second type he described as the medium-duty motorcoach which seats from 17 to 25 passengers and has largely been made up from truck parts; their performance in general has been poor, the powerplant has been too small and the proportions of the chassis generally inadequate. These conditions have been changed and vehicles of a very satisfactory type in this class are now being produced and marketed. The heavy-duty motorcoach, seating from 25 to 40 passengers, constitutes the third class. Vehicles of the smaller capacity in this class are in general use by public-utility companies throughout the Country, both for urban and interurban service and including long-distance transcontinental day-and-night operation. In the larger sizes, the 40-seat-capacity type is comparatively new in the field and has aroused considerable interest.

For urban operation, Mr. Green said that the present types in use seem to give fairly satisfactory results, although in the larger units more power would be welcome; but in interurban service, particularly for long-distance high-speed runs, the performance is in general decidedly poor because all such vehicles are underpowered. As to the interurban types, these vehicles lack what the public most desires; that is, automobile service from the viewpoint of acceleration and speed. More than one size of powerplant is necessary if a manufacturer enters this class of motorcoach building because the larger engines, which are so needed for interurban high-speed runs, are not so necessary in urban operations. In the latter case smaller engines can be used and the difference in power can be compensated by decreasing the gear ratio. The speaker then discussed the powerplant situation in detail, and also other features of design.

DIFFICULTIES TO BE OVERCOME

As nearly everyone realizes today that all vehicles for passenger transport are in the automobile class, the only difference between the automobile and the motorcoach is in the number of seats provided, according to Mr. Green. The public is demanding the same performance from motorcoaches as it is accustomed to get from its own private automobiles with regard to safety, comfort, appearance, speed, acceleration and deceleration. The difficulties in obtaining such performance for the motorcoach include considerations regarding the dimensional restrictions on the size of the vehicles, the weight and capacity of engines and the possibilities for gasoline-electric and for steam propulsion.

In conclusion, Mr. Green remarked that there is every reason to be optimistic for the successful future of the motorcoach. This industry has been developed almost entirely, he said, as a result of the pioneering efforts of the individual operator, whose courage, conviction and hard work brought the

motorcoach business into being, a marvelous performance when it is remembered that the individual operator in the early days did not have the support of the manufacturers or of the large-scale users. The speaker suggested that all the engineers present try to influence their respective organizations to appropriate adequate sums with which to develop the motorcoach, particularly the high-speed interurban type. Concentration of effort is needed to change the condition of legislation which affects the progress of motorcoach development adversely because of dimensional limitations that cannot be changed except through the process of modifying public opinion. He urged all his hearers to realize the necessity for being open-minded on the subject of motorcoach development.

PROFITABLE MOTORCOACH OPERATION

Fitting the motorcoach to the transportation needs was discussed by Mr. Graham with special reference to urban transportation. This phase of the industry has progressed, he said, from a status in which the motorcoach was not regarded as a factor to the present situation in which hardly a city transportation company exists which does not make use of the motorcoach in some way. However, the development of a vehicle for mass transportation of passengers has been handicapped by the small size of the vehicle, its higher cost of maintenance and power per mile, and its much higher rate of depreciation compared with electric street-cars. The natural process of future development is to ameliorate or remove the present disadvantages.

It is as natural to attempt to use the entire wheelbase of the vehicle for revenue-producing purposes as to use the entire wheelbase of a street-car, in Mr. Graham's opinion. If use is made of a generator and motors to convey electrical energy to the wheels, the engine can be located anywhere in the vehicle in any position. It seems fairly certain that whatever progress has been made along this line will be increased greatly in the future.

The experience of many companies indicates that, even with the ordinary conventional type of motorcoach, a useful life far beyond what has heretofore been considered good practice can be anticipated. As a result of development, the motorcoach is taking equal rank with the street-car in passenger-carrying capacity, and no reason exists why the excessive depreciation of the motorcoach should not be reduced to a figure comparable with street-railway operation.

MUST COORDINATE SERVICES

Use of the private automobile by families that formerly used the street-cars has not eliminated the need for public transportation agencies; it has simply altered the characteristics of such agencies, according to Mr. Graham. As the use of the automobile increased, the net effect, so far as the transportation line is concerned, was a thinning out or decreased potential number of customers on the line. This is a fundamental fact that must be faced by the public transportation companies, in the speaker's opinion.

As the use of public transportation facilities decreases, no economic warrant or basis exists for an increase of public transportation facilities, hence there must be coordination, said Mr. Graham. Where the motorcoach is the better economic vehicle to use, transportation should be furnished by it alone; and where the street-car is the more economical vehicle, there should be no parallel service by motorcoach. Intensive study should be given to the determination of the conditions under which each type of vehicle can be most efficient.

In determining the cost of operation, Mr. Graham segregated the charges into four groups: direct operating expenses, depreciation, interest on the investment, and taxes. Direct operating expenses consist, he said, of maintenance of way and structures, maintenance of equipment, power, transportation and traffic, general and miscellaneous. These classifications were discussed in detail to show how the proper procedure can be developed for accounting that will afford a basis for statistical comparisons.

PRACTICAL MOTORCOACH MAINTENANCE

Maintenance of motorcoaches is a phase of operation, said Mr. Hughes in discussing the factors and systems that constitute efficient motorcoach service. While maintenance influences the other phases of operation, it likewise is influenced by them.

The principal factors contributing to effective economical maintenance are adequate, well-equipped shop-buildings for proper storage, inspection and repair; an efficient maintenance division composed of skilled mechanics and shop men under a competent supervisor; a carefully arranged inspection system systematically adhered to; and a practical means of cooperation between the mechanical division and all other divisions of the motorcoach-operating organization. In other words, there must be a management which knows how to coordinate the work of the entire organization so as to assure the most satisfactory service at the lowest possible cost.

Mr. Hughes outlined the organization of the Baltimore company he represents and described its methods of motorcoach operation. The fleet consists of 107 motorcoaches, of which 14 are 55-passenger semi-enclosed double-deck vehicles. Excepting a few motorcoaches for special service and for sightseeing, the remainder are single-deck vehicles of 25 or 29-passenger capacity and of the standard pay-as-you-enter city-service type. In addition, the company operates 38 motor-trucks and 24 automobiles.

His company's methods of maintenance were outlined by Mr. Hughes, who also submitted voluminous statistical data of revenue and expense and explained how these statistics are compiled and utilized. He then described the effect that departmental cooperation by the entire organization has on maintenance costs and effectiveness, pointed out practical methods of accomplishing this result in a motorcoach-operating organization, and directed attention to the possibility of utilizing statistics of service calls to control the expenditures of the maintenance division.

In conclusion, Mr. Hughes remarked that an organization is operated blindly unless it has a suitable accounting system correctly carried out and properly used. The statistics and data prepared by the accounting division are the eyes through which the executives see what the business is doing and what they can make it do.

Fuel Feed in Philadelphia

DISCUSSION of the proposed reorganization of the Society according to the activities of the members occupied the first part of the meeting of the Pennsylvania Section, on Dec. 12. The subject was presented by B. B. Bachman, Past-President of the Society, and has been recorded for consideration by the Reorganization Committee.

Chairman Adolph Gelpke, of the Section, then turned the gavel over to C. C. Trump, who introduced as the speaker of the evening F. G. Whittington, chief engineer of the Stewart-Warner Speedometer Co. Mr. Whittington presented a paper which was an amplification of his Semi-Annual Meeting paper, printed in the S.A.E. JOURNAL for December, 1928, p. 602, and discussed fuel-feed devices of many types. The first was the vacuum-feed system, including the booster, the trap valve and the vacuum pump, devices for maintaining a vacuum under engine-operating conditions producing insufficient vacuum in the inlet pipe. The vacuum tank itself has been simplified in the latest models, and its size can be materially reduced when provision is made for constant vacuum by one of the devices described. All of them were illustrated by slides and further described by Mr. Whittington while the slides were being shown.

Other fuel-feed devices included in the paper were an electromagnetic

fuel-pump, a mechanical fuel-pump, a carbureter, a combined carbureter and electric pump, and the direct fuel system.

DIRECT FUEL-FEED

The combination of fuel-pump with the carbureter makes a very desirable arrangement, according to the speaker, but greatest interest was shown in the direct fuel-feed system. In this system, a rich mixture of air and fuel is drawn from the fuel-tank to the engine, where it is mixed with more air before entering the cylinders. The speaker prophesied that, although this is a radical departure from present carburetion practice, it is a system of which we shall hear much during the next few years.

Among the discussers were Edmund B. Neal, of *Automotive Industries*, and R. W. A. Brewer, both of whom reported interest in a direct fuel-feed device since about the beginning of the present century. Captain Brewer said that this development is leading toward gas-engine conditions by providing a fixed gas that can be mixed with air at the engine, rather than an emulsion of air and liquid gasoline, and that it may eliminate many of the present undesirable conditions.

Increasing Airplane Speed-Range

Spanish Engineer Tells Milwaukee Section of Devices for Improving Control at Slow Speed

MAKING a metropolitan newspaper was illustrated in a three-reel motion-picture at the opening of the Dec. 5 meeting of the Milwaukee Section. The meeting was preceded by a dinner, at which the registered attendance was approximately 65. Chairman Cyrus L. Cole presided and introduced the speaker, Heraclio Alfaro, who was one of the early European aviation experimenters and built and flew his own planes before the World War.

At one time Mr. Alfaro was in charge of the army aviation instruction at the flying-school in Madrid. Since coming to this Country he has pursued post-graduate work at the Massachusetts Institute of Technology and has received various honors and prizes in airplane-design competitions, including a competition for all-metal airplanes held at McCook Field in 1920. The paper he presented at the Milwaukee meeting last month is intended as a competitor for the Wright Brothers' Medal. In his present development work in Cleveland he is associated with D. S. Ingalls, who is said to be the only American Naval ace.

Recommendations made by the Daniel Guggenheim Foundation for the safety and efficiency of aircraft are believed by many to be very complete and well-balanced but they cannot be met by any present airplanes, Mr. Alfaro said. They require very high speed-range, satisfactory response of all controls at any altitude and at angles above that of stalling, and a steep climb and glide. At the same time, 5 lb. of useful load per horsepower of the engine is specified.

These requirements seem to call for variable lifting units, improved rolling-control arrangements, improved provision for longitudinal stability, reduction of parasite drag, rational utilization of available engine-power in climbing, means of increasing drag and of braking in landing, and reduction in fire hazards. Improvements also are desirable in visibility, heating and ventilation, and in protection from the weather.

Variable-lift units contribute to safety by extending the speed range. Most accidents occur in taking off, landing or in flying blind. Under all these conditions the pilot is likely to be flying at the minimum speed. Providing lower minimum-speed reduces the personal injury likely to result from a crash, because this is proportional to the square of the velocity.

WING-FLAPS REDUCE STALLING SPEEDS

Analysis of the conventional wing-flap leads Mr. Alfaro to the conclusion that probable impact-pressure can be reduced about 27 per cent by their use, thus contributing substantially to safety. The Handley-Page slotted wing retards the burble point and makes practicable higher angles of incidence without stalling.

Some account was given of tests of airplanes with experimental wings having an improved form of flap designed by Mr. Alfaro. This has been developed into a semi-automatic control and seems to have promise.

Spoilers, which provide powerful rolling-control at large angles of attack, are devices placed near the leading edge of the wing to destroy the lift and increase the drag. They could control landing at speeds below the stalling speeds. The speaker described a method of control by a combination of ailerons and spoilers that he has developed on an experimental airplane. Tests of this plane have not proceeded far enough to be conclusive but are said to show promise of exceptionally good results in control at low speeds.

Downwash from the fuselage and the slipstream from the propeller sometimes have an important influence on the effect of the tail control-surfaces. Mr. Alfaro has found it advantageous to locate these surfaces high to minimize this influence.

REDUCING PARASITE DRAG

Parasite drag becomes much more important as speed rises, so that the effect of an increase in engine power may be neutralized if the more powerful engine introduces greater drag. The influence of drag on speed is almost inversely proportional to the square root of the drag, while the influence of power is proportional to its cube root. It has been recognized that cowling in a radial engine helps the speed of an airplane, but few realize how much help it can give. In one case, according to Mr. Alfaro, a single-seat plane was increased in speed from 118 to 137 m.p.h. by such cowling. Landing-gear and wheels also contribute largely to parasite drag, and this resistance can be cut down by covering a large part of the wheel and adjacent strut with cowling, which can also serve as a mudguard to prevent fouling of the fuselage with mud that would increase its resistance in the air.

Lifting-struts are considered as a possibility to make useful a large amount of frontal area. Developing them into supporting surfaces has not, however, proved profitable.

Common use of variable-pitch propellers in the near future was prophesied by Mr. Alfaro, who said that a propeller of this type can increase the rate of climb 33 per cent and increase the angle of climb from 9 deg. to 14 deg. The variable-pitch propeller can be made smaller in diameter than the usual design and can give the airplane higher speed.

GLIDER DESIGN OFFERED

In a second section of his paper the author gave a detailed description of a glider that is said to weigh 140 lb. and to be capable of carrying a 170-lb. man. Fittings have been eliminated so far as possible in the design, and those that are used are made from plain steel straps. Piano wires are used for the bracing, and all the material is in simple form.

It is intended to make this design available to manufacturers who will supply the material complete for amateur builders, together with drawings, photographs and instructions for building. The glider can be launced in the face of a wind from the top of a hill, or it can be towed by an automobile with the help of a drum adjusted to

prevent excessive pull from anything like a gust of wind.

In response to questions, Mr. Alfaro said that few airplanes can be landed at speeds of less than about 55 m.p.h., and few have a speed range as great as 3 to 1. From his plane he expects to obtain a maximum flying-speed of 150 m.p.h. and a stalling speed as low as 35 m.p.h.

Preventive Maintenance-Methods

Principles of Local Motorcoach-Fleet Operating-Practice Outlined for Cleveland Section

THE policy of the Cleveland Railway Co., which operates a fleet of motor-vehicles, defines the undertaking as well as the ideals of its founders and sets forth the methods to be used so that the undertaking will be successful, according to Leonard Rose, assistant superintendent in charge of maintenance of the company's motorcoach department, who presented his paper on Automotive-Equipment Maintenance at the meeting of the Cleveland Section held at the Cleveland Hotel, Dec. 10. Continuing, he said also that the degree to which an undertaking will succeed depends entirely upon the soundness of the policy and the intelligent and sincere efforts put forth by the entire organization to further the ideals for which it stands. An effective maintenance program therefore must in no way conflict with the company's policy.

At the dinner which preceded the technical session, 147 members and guests were present; at the technical session, presided over by Ferdinand Jehle, an audience of nearly 200 greeted the speaker. Before the speaker of the evening was introduced by E. R. Jackson, of the White Motor Co., Chairman Jehle took occasion to show a lantern slide picturing the proposed reorganization chart of the Society, a copy of which was included in the December issue of the S.A.E. JOURNAL, and to explain the major advantages which it is hoped will result from its adoption. He recommended that members study this chart carefully and send their comments and criticism to the headquarters office of the Society.

FUNDAMENTALS OF SUCCESS

Mr. Rose attacked the problem of maintenance from the viewpoint of a maintenance man who is confronted with the task of building an organization to care for a fleet of motor-vehicles composed of passenger-cars, motortrucks, motorcoaches, taxicabs or whatever composite of these types may be assembled in a fleet. He said that the problems of the various types of maintenance differ in detail but that the fundamental problems remain the same. Successful operation depends upon keeping the fundamentals in mind. The maintenance executive not only must have a comprehensive mechanical knowledge but, to build a good organization, he must be thoroughly conversant with various other factors which are not of a mechanical nature but are of equal if not greater importance. These factors are:

(1) The policy of the operating company
(2) A comprehensive and detailed knowledge of what kind of service the rolling-stock will be expected to render
(3) The type of equipment available on the property or in the market
(4) The economics of good maintenance
(5) In what average standard of repair the equipment should be kept
(6) The type of personnel necessary and available, together with an educational program for the mutual benefit of employe and employer
(7) The control of results by conversion of pertinent statistics into suitable standards for the measurement of all types of performance, and how this can best be done

With the foregoing fundamentals in mind, Mr. Rose went on to outline the considerations involved for each item, with special reference to the maintenance methods in use by the company he represents. He remarked that the satisfaction which can be derived from a transportation service and the extent of the maintenance problem depend largely on the vehicles used and how wisely they were chosen with respect to all of the fundamentals involved.

ANALYSIS OF EQUIPMENT

The responsibility of the supervisor of maintenance includes an analysis of the equipment from the viewpoint of its adaptability to the transportation problem as a whole. The factors of this analysis and the sources of information are: (*a*) records of performance of vehicles already in the service; (*b*) records of performance of the same type of vehicle in similar services elsewhere; (*c*) a knowledge of what types of equipment are available in the market; (*d*) records of performance of these types in service that is comparable with the service being considered; (*e*) a knowledge of general practices that results from past experience, which is obtained from the trade periodicals and by exchanging ideas with others engaged in the same or allied fields. Equipped with the foregoing information, the fleet supervisor is in a position to improve the specific operation for which he is responsible.

Continuing, Mr. Rose stated that the economics of good maintenance should dictate to what extent replacements either of whole units or their integral parts are to be made. It should also dictate what shop equipment and how much building space are to be provided. No capital expenditure is justified unless a return is assured either in the form of new capital or of a saving to be effected by such an expenditure. However, any planning that does not take into consideration expansion is not economically sound, even though it is productive of efficient operation at the time it is inaugurated. It must also be remembered that there is some repair work that can be done more economically by the manufacturers of the individual unit, or by specialty service-stations, even though the charge for labor be more than that of the maintenance organization. Here, volume of similar repair work is the chief controlling factor.

CONSIDERATIONS REGARDING PERSONNEL

In Mr. Rose's opinion, the problem of personnel is the most important one confronting the maintenance executive. The personnel should be studied from the viewpoint of matching the qualifications of the individuals with the requirements for the shop. The workers must be reasonably contented in their work and must have some incentive in the way of advancement so that they will continue to do good work and broaden their viewpoints. Means for preventing stagnation in the organization should be sought continuously. All positions that become vacant should be filled by promotion from the ranks whenever possible. The maintenance executive should familiarize himself with the sources of labor supply, and the men employed should be chosen, so far as possible, with regard to their potential executive ability.

Organization control of results can be accomplished best through the medium of friendly competition. The employe's pride in the organization and in his work should be stimulated so that he will enter into competition with the other members of the working force in the right spirit.

Preventive maintenance may well be chosen as a slogan for successful fleet

operation, according to Mr. Rose. The major activities of the organization must consist in making predetermined repairs at regular scheduled periods. Any system is only as good as the men behind it and the honesty with which they use it. It may be a means for formulating alibis but, if properly designed, the system will be a means of detecting and thereby curbing them. The personnel must be convinced that if the system is followed it will help them to better themselves by pointing out their mistakes, and that the thing which really counts is not so much who made the mistake but what mistake it is and why it was made.

Daily inspection, weekly inspection, and general inspection are practiced by the Cleveland Railway Co., in line with its preventive-maintenance policy, and Mr. Rose described the details and procedure which apply to them and illustrated these with charts and record forms. The general inspection is based on a mileage schedule, and a list of the things which must be done at certain specified mileages of operation was presented, together with a description of the method of making the necessary records and of utilizing them.

Guesswork Largely Discounted

In setting up the company's repair and overhaul program, Mr. Rose said that the element of guesswork is eliminated to the greatest extent possible by providing instruments and standard testing-apparatus for determining the actual condition of the various units both before and after repairs are made. He outlined the shop organization and the major items of shop equipment and described the shop methods. A well-balanced supply of repair parts is maintained, and the parts record-system is of the perpetual-inventory type.

Summarizing the work of his organization, Mr. Rose stated that it applies to the operation of 175 vehicles, including motorcoaches and motor-trucks, and to a departmental personnel of 128 men, including himself. The motorcoaches operate 380,000 miles per month, or at the rate of 4,500,000 miles per year. The gasoline consumption is approximately 97,000 gal. per month. The methods described have raised the standard of operation continuously while reducing the cost per unit. In Mr. Rose's belief, the fundamentals upon which the system is based can be applied with equal success to other types of motor-vehicle maintenance.

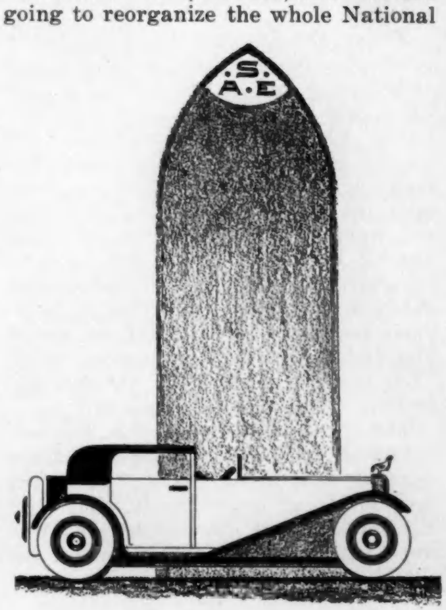
The discussion centered largely on the subjects of what items should be included in overhead cost of maintenance and on the means for reducing this cost. Other subjects considered included the means for finding out the actual condition of a vehicle without operating it on the road before inspection, reasons for the employment of certain special tools in the shop, methods of stock-keeping, reduction of surplus stock to the minimum, and the maximum amount of mileage at which spark-plugs can be expected to function satisfactorily.

Bodies Abroad and Here

Detroit Body Division Hears Designs Compared by Hill, Dietrich and Sakhnoffsky

In the time-honored phraseology of the country newspaper, enthusiasm ran rife and a good time was had by all at the Body Division meeting of the Detroit Section on Dec. 10 at the Book-Cadillac. In this instance "all" means 520 members and guests at the dinner and entertainment and 600 at the technical meeting. Great interest in body lines was shown during the entertainment when the dancing girls came on to do their turn. Because, in the words of Chairman William Davis, 50 per cent of the entertainment would have been lost if it had been put on during the dinner, it was held after the food had been consumed with the usual neatness and dispatch. Several men from The Kentucky Colonels, which was playing in a local theater that week, did some dancing and singing turns, and three negroes dressed in sailor costume also entertained the members with their vaudeville performance.

Preliminaries in the technical meeting were run off quickly because three papers were on the program for delivery. B. J. Lemon, Chairman of the Section, said that the meeting of the Body Division typified the spirit of the "new" Detroit Section, which did a big thing last year when it organized the Body and Aeronautic Divisions. The man who "put over" the idea of the separate divisions in the Section now has another idea, he said, and "we are going to reorganize the whole National Society so that it will have divisions or activities, with men in charge of them who are interested in the particular work of each division." Mr. Lemon referred to the reorganization chart in the December S.A.E. Journal and invited the members to study it and attend the business meeting at the Annual Meeting on Jan. 15 prepared to offer objections to or encouragement of the plan.



Annual Meeting Body Sessions

Chairman Davis, of the Body Division, then told of plans for the Body Sessions at the Annual Meeting on Wednesday afternoon and night, Jan. 16, which are to be conducted by the Detroit Section Body Division. "Pop" Kreusser, manager of the General Motors Proving Ground, is to review the automobiles of 1929, telling wherein they are attractive or unattractive to the public mind. The afternoon session is to be divided into three sections, one on insulation against vibration and noise, another on ventilation, and the third on color analysis.

Meeting the objections that had been voiced by some members that the Detroit Section meetings are not now engineering meetings but parties, Chairman Crawford, of the Meetings Committee of the Section, told of plans for a highly technical meeting on Feb. 11, at which R. M. Janeway is to give a paper on combustion-chamber design. Down in Indianapolis, where he came from, said Mr. Crawford, the Indiana Section has a great deal of discussion. The only way to make technical discussion a success is for those who are interested to get up and say something. He is going to try to have such a discussion in Detroit and see whether the members like that kind of a meeting or prefer parties.

Lemon Peaches on Hill

An endeavor was made by Chairman Lemon to introduce "Clayt" Hill, of the Murray Corp. of America, as the first real speaker of the evening by relating several anecdotes about him as a reflection of, or on, his character. During Clayt's school days in Detroit, when a teacher asked what pupil could name an important date in history, Hill raised his hand and shouted, "I can; Antony's date with Cleopatra." When he was Meetings Manager of the

Society, Hill staged at West Baden, in 1921 or 1922, one of the hottest National Meetings the Society ever held. When someone remarked, "Pretty hot, Clayt," he replied: "Yes, we should have a thaw except for one thing—there isn't anything frozen." On a recent European trip Hill had lost his baggage when he reached London but he looked through his monocle into the chilly eye of a room clerk at one of the high-class hotels on the banks of the Thames and asked for a room. "Have you any baggage?" asked the clerk. "I have 54 pieces; it is following me," was the reply. So he got the room and the next day the clerk apologized when Hill told him his baggage consisted of a pair of socks and a deck of playing-cards.

Foreign Show Impressions

When Mr. Hill rose to speak, however, he intimated that Mr. Lemon had not been meticulously correct, as they were not playing-cards but probably French postcards showing body lines. Perhaps it was from these that he derived the inspiration for his address on the general impression he drew last fall from the Paris and London automobile shows, which are fortunate in having adequate and architectually appropriate buildings for the display of motor-cars and accessories.

Anyone visiting the foreign shows in search of novelties in body design failed to reap the reward of previous years, according to Mr. Hill. European and American designs are becoming more and more alike, through the designers of both continents copying the best points and touches of the other. It is worthwhile for any American body designer to visit Europe for the inspiration to be gained in an environment that is assuredly esthetic. Mr. Hill found that almost all the attractive coach work was on long-wheelbase chassis, while appearance of the small cars was unattractive. In the effort to make cars appear very low, designers carry the body sides well below the frame in many cases, even to the running-boards, with splashers eliminated. Mr. Hill said he gained the impression that the deep-sided close-coupled four-passenger cabriolet is an interesting type that may find favor in the American market, supplanting the coach, the roadster or the sport phaeton because of its greater utility.

The speaker went on to discuss various exterior details, including molding and window treatment, and said that roofs are thinner as a rule than on American cars, that French rooflines seem almost standardized with the highest point well forward, usually above the third pillar, and that the large number of backwardly inclined fronts was impressive.

European cars show pronounced superiority in interior comfort and beauty, and Mr. Hill expressed the thought that in this Country we have let price rule to too great an extent, and that the first American manufacturer to make a strong selling-point of extremely comfortable seats will capture much public approval. Many types of adjustable seats that can be moved fore and aft were seen at both the Paris and London shows, and there were instances of American bodies having been altered in Europe to incorporate adjustable front seats.

There is a decided trend abroad to collapsible tops on closed cars and to cars in which the top slides, folds or rolls back, leaving roof rails and doors in position.

Much is being done by Continental as well as American designers to clean up the exterior. Several designers, in contrast to our tall radiators with false bases, cut their radiators off at the frame line and run flat splashers forward at the level of the frame members.

Get Ideas from Nature

The second speaker was Raymond H. Dietrich, of Dietrich, Inc. He acknowledged a debt of gratitude to Andrew Johnson, who trained many body designers in the possibilities of the use of the ellipse, the circle, the rectangle and the triangle as the foundations on which design is based, and also suggested that objects in nature show the best varieties of the curve and the ellipse. Whereas straight lines express stillness and repose, said Mr. Dietrich, curves suggest motion.

Artistic knowledge which the designer especially acquired is no longer his exclusive possession but is shared by the motor-car manufacturer, who has trained himself to see superiority and distinction in a quality design. His interest in a new body begins with the earliest sketches, and his ideas are valuable.

Today the designer is trying to express the opinion of the individual and collective buyer, irrespective of the price field in which he buys, who now knows what he wants and can tell clearly what he wishes to see. The manufacturer who attempts to force upon the public something that it does not want, said Mr. Dietrich, will find himself in the fix of the little colored boy who fell asleep in a watermelon patch in the course of eating an enormous melon. When the farmer awoke him and, pointing to the melon, asked, "Too much watermelon?" the boy answered, "Nope, too little nigger."

The speaker suggested that the definition by John D. Rockefeller of the chief element in success as "Doing the common thing uncommonly well" has a serious import for designers, who work with ordinary materials but see shapes and lines in imagination.

The latter half of Mr. Dietrich's address was devoted to observations made and impressions he had gained at the Automobile Salon in New York last December, in which he interspersed numerous amusing anecdotes.

How Europeans View Our Cars

Friendly and constructive criticism of American car design was made by the last speaker, Alexis de Sakhnoffsky, who has assumed direction of the newly created art department of the Haynes Body Corp. Being primarily an artist, he is concerned with creating new designs and does not take the trouble to see whether an idea is readily adaptable to production. For this reason, and because it is important to have the body and chassis designs blend into a harmonious ensemble, he believes it is desirable to have chassis designers and production engineers work in very close cooperation with the body designer. An advanced idea which the speaker advocated some time ago in Paris is that, in developing a new car design, the working out of the whole external and internal outline should be placed in the hands of "mechanical" artists, without interference by body engineers, so that every part of the car and its mechanism shall be artistic. Only when the general lines have been fixed should the body and mechanical engineers go into action to work out the mechanical details so that they fit into the visualized chassis and body.

Large-scale-production body designers, thinks Mr. Sakhnoffsky, should study the trends in custom-body building and follow them more closely in production. Although the present trend is to lengthen the hood and cowl as much as possible and to emphasize streamlining, almost all car builders in America nickel-plate the cowl bead and so break up the longitudinal effect by a bright transverse and vertical line. American cars all look much alike because they do not have the distinctive touch possessed by the custom body, which should be the designer's aim to attain. To accomplish this it is not necessary to use more expensive materials and extra labor, but only to obtain the best curves and the right colors.

An expensive-looking front cannot be given a car with flat, short, high-mounted fenders, which are reserved in Europe exclusively for light sport-cars, according to the speaker. Outlines of dials on the instrument board are being simplified as much as possible in Europe, whereas here the majority of cars have elaborate engraving or etching that is out of keeping with the modern car. Symmetry should be foremost in instrument-board design, and a clean, simple but not bare design can give real pleasure to the eye.

Mr. Sakhnoffsky expressed great admiration for the design of interior

hardware on medium-priced American cars, and said that attractive hardware is rarely found in European automobiles. But if elaborate hardware is used, it should have an extremely simple setting, whereas if the interior of the car is elaborate and colorful, the hardware should contrast with it by simplicity.

In conclusion, the speaker referred to the lack of attention given to the front and rear appearance of most cars; lines should be designed, he said, to harmonize from all points of view.

Booster Brakes Boosted

Fluid-Actuated Brakes, Power-Operated and Hydraulic, Discussed in Southern California

MAKING their contribution on the subject of brakes, which is a popular theme for Section meetings this season, nearly 100 members of the Southern California Section met at the Los Angeles City Club on Dec. 7 to hear and discuss papers by Joseph O. Moore, on the B-K brake booster; by C. D. Stewart, on Westinghouse automotive brakes; and by C. Stevens, on the Lockheed hydraulic brakes. Section Chairman Joseph O. Moore announced at the opening of the meeting, which followed a dinner attended by 75 members, that the January meeting of the Section will be held during a morning and afternoon in connection with the Western Metal Trades Convention, instead of in the evening. The date will be announced to members of the Section soon.

In his paper on vacuum brake-boosters, Mr. Moore traced the development to the foresight of James S. Dickson, of Los Angeles, who began work on a floating-piston assembly at an early date and was granted a patent in 1913. Ray Thomas, president of the Electric Equipment Co., purchased this patent and spent several years in experimenting and further developing the idea, finally developing the double-seat, triple-acting valve that is in successful use today. This valve keeps the cylinder constantly in a condition of vacuum, so that it is always ready for action, and two or three power applications of the brake can be made with the engine dead.

In passenger-cars, where economy is secondary to ease of application, soft brake-linings are used. These require frequent adjustment and renewal. For commercial cars, where economy is primary, harder linings giving longer life and requiring greater application-pressure are in common use. This is said to create a hardship for the operator of a heavy vehicle having four-wheel brakes of large diameter, and brake boosters relieve this condition.

Faster runs have been found possible with the better control given by power-actuated brakes. A Los Angeles oil company has been able to reduce the time for covering a local delivery route from 10 to 7½ hr. by this means, and a suburban delivery run was reduced in time from 4 to 3 hr. The latter comparison was checked by repeated tests in which the drivers alternated; and was followed by application of a booster to the second truck, thus bringing its running time down to that of the first.

Another advantage claimed for the B-K system is that it draws into the engine the air, admitted to the vacuum cylinder during brake application, after the stop has been completed, rather than during the stop when there is more danger of killing the engine.

Mr. Moore concluded his paper with descriptions of several interesting applications under exceptional conditions, such as the control of a large power-shovel on the St. Frances dam and of a 100-ton low-bed trailer.

Vacuum and Air Brakes

Vacuum brakes were said by Mr. Stewart to relieve the difficulty in servicing self-energizing brakes, as well as to reduce the pedal pressure and stroke required. In the Westinghouse system the brake-application pull is three times that resulting from the pedal-pressure exerted by the operator, thus retaining for the operator the "feel" of brake applications and control.

Construction of these brakes was thoroughly described with the aid of diagrams. They are made in two sizes for passenger-cars and in a larger size for medium-weight motorcoaches and motor-trucks. Assuming a vacuum of 15 lb. per sq. in., and average leverages, these units develop brake-rod pulls ranging from 660 to 1197 lb.

In the discussion following the three papers, Mr. Stewart said that Westinghouse air-brakes are made for the heavier road-units, including tractors and trailers. They are particularly adapted to automatic application in trailer service.

Hydraulic Type Described

Hydraulic brakes were discussed by the last speaker, with particular reference to the Lockheed brake, said to be founded on the basic principle of hydraulics laid down 300 years ago by Pascal. Four-wheel hydraulic brakes were introduced in 1920 as an accessory for a certain large car on which excessive pedal-pressure made desirable its combination with a vacuum booster.

Mr. Stevens described briefly the successive models of external-band, three-shoe-internal and two-shoe-internal brake, the last with the compensation for expansion in the master cylinder.

The liquid used for the first hydraulic brakes was a mixture of alcohol and glycerine. In reply to a question, Mr. Stevens said there had been trouble, under extreme heat conditions such as are encountered in Death Valley, from vaporization of the alcohol. This trouble has been corrected by using a fluid that does not vaporize. Trouble of the same sort was reported by a discusser in connection with some experimental work in which 10 hp. was absorbed continuously in one brake, raising it to a dull-red heat in a period of 20 min. It required 10 or 15 min. for the fluid to return to its normal condition.

Rivetless Brake-Shoes

Something new in brake-lining application was described by Don Lincoln, of the Python-Grip Brake Co. The lining is attached to the band by means of a series of notches, eliminating rivets. It is in the form of pads or clips, between which clearance spaces of about ¾ in. are left to preserve the pliability of the band. This is said to be an advantage also in freeing the brake of grit and water, reducing the abrasion on the drum and improving braking in wet weather.

A secret of metal-shoe durability was revealed by J. C. Helm, of the Westinghouse Air Brake Co., who said that some of the best metal brake-shoes had been made from materials secured from the plates of a junked battleship. After this material was exhausted, the mileage on brake-shoes dropped from 20,000 miles or so to about one-fifth of that mileage.

Midvale tire steel, secured from tires discarded from interurban and steam-railway trains, was found to be as good as the armor plate. The same quality of steel secured from the steel makers was found not to be durable without the seasoning it received in the railway service, and spring-steel shoes were substituted. These are found to be very durable, but there is some trouble from brittleness if they are tempered too hard. Mr. Helm said that the latest improved fabric linings are very durable, and he considers them preferable to metal linings.

There was some discussion of controls for trailer brakes, during which Mr. Moore described two methods of control, one with a three-way valve on the dash, controlling brakes of the truck and trailer simultaneously, and the other giving independent control in

the trailer. He favored the latter method, in which the braking can be applied under certain conditions to the trailer only, but can be shifted to the truck in case their use is sufficient to heat excessively the trailer brakes. This arrangement parallels recent railroad-brake practice, in which it is found best to apply the brake control to a train in two sections, making it possible to eliminate objectionable slack and bumping in the train.

Modern Automobile Finishes

Chromium-Plating and Cellulose-Nitrate Body Finishes Discussed at New England Meeting

SUBJECTS chosen for the Dec. 12 meeting of the New England Section because of their interest to a majority of the members, who are not design or production engineers, were Chromium-Plating and Its Advantages, by J. W. Kilduff, of the Aga Auto Lamp Co., and External Body Finishes of Automobiles, by G. C. Given, of the Parlin, N. J., works of E. I. du Pont de Nemours & Co. Fifty-two members and guests were in attendance at the Engineers Club in Boston, where the Section dinner was served at 6.30 p. m. Chairman Knox T. Brown presided.

Mr. Kilduff briefly described the characteristics of chromium and its advantages as a plating material, then explained that the long delay in making practical application of chromium-plating was because of the large number of variable factors involved in a chromium-salt solution and also because of the behavior of chromium in regard to its "throwing power" or ability to plate inside surfaces, grooves, corners and so forth. Some of the early chromium solutions were so inefficient that a current density of 900 amp. per sq. ft. was not uncommon, as against 7 amp. for nickel and 28 amp. with the average acid copper-plating solution.

In almost every case now the acid bath is conceded to be best for chromium-plating. It is composed of a very concentrated solution of chromic acid combined with small proportions of other salts that assist in preparing and maintaining the throwing power of the electrolyte. Insoluble anodes are used, so that all plating is done directly from the solution.

Flat Lead Anodes Now Used

Current densities are still very high, ranging from 75 to 450 amp. per sq. ft., as both anode and cathode efficiencies are very low. Whereas several years ago it was necessary to build an anode similar in shape to surround the article to be plated, and suspend it at a distance of about 4 in. from the surface, it is now possible to plate articles with irregular surfaces from flat anodes 2 ft. distant.

Practical experience shows that lead is the best material for the anode, according to Mr. Kilduff, as it is insoluble in the solution and the strong tendency to form oxygen at its surface during the plating process assists in maintaining the chromium ion at its proper valence.

When the high electric current from a 1500-to-2000-amp. generator is switched on, the large quantity of oxygen generated throws a heavy, reddish-brown spray from the surface of the solution and a blower system is needed to draw off the irritating fumes. With a suitably equipped tank, the health of the operator is not endangered. The high current also makes necessary the use of work-carrying racks that provide good contacts and generous-sized conductors for the current. A new operator not infrequently overloads the fixture, thereby causing the hook to melt and the work to fall to the bottom of the tank. As each piece must be plated separately on a rack or in a single layer on a wire mesh at high voltage, no truly economical way has yet been devised to chromium-plate such small particles as screws and rivets, said Mr. Kilduff.

Luster without Buffing

Resistance to tarnish is the property of chromium that appealed most quickly to the public, and this, with its attractive color, makes it ideal as a metal finish. When used for appearance alone, an attempt is made to balance the current densities so that the work will leave the solution with a desired luster that does not require buffing. In the case of special shapes, the best results are obtained by the use of mixtures which protect the high points from over-plating.

Proper preparation of the surfaces before plating is most important where a bright finish is desired. Scratches or other defects are never covered up satisfactorily, but in most cases are intensified by the plating. As given by the speaker, the most satisfactory procedure for bright-plating steel parts is as follows: (*a*) polish the surface with emery, grading from 120 to 180; (*b*) buff; (*c*) nickel-plate for 15 min.; (*d*) copper-plate for 30 min.; (*e*) color copper; (*f*) nickel-plate for 45 min.; (*g*) color nickel; (*h*) bright chromium-plate for 3 to 5 min.

This not only gives a brilliant finish but also affords the best-known protection against rusting.

To bright-plate on brass, the method is much simpler, as follows: (*a*) cut down, buff and color; (*b*) nickel-plate for 45 min.; (*c*) color nickel; (*d*) bright chromium-plate for 3 to 5 min.

Zinc, tin and aluminum can be chromium-plated in a similar way, although it is extremely difficult to make any plate adhere firmly to an aluminum surface. It is also unsatisfactory to plate directly on brass, as the plating peels off after exposure to weather for a few months.

Action of the gas formed in chromium-plating is so severe that it loosens any nickel or copper-plating that has not been properly applied; in fact, most of the rejections from the process are caused by failure to clean the work 100 per cent in advance.

Uses on Wearing Parts

Next to its resistance to corrosion, the hardness of chromium is its most valuable property. For this reason it is used where great resistance to wear is desired. It also has an extremely low coefficient of friction, hence has been used on wristpins, crankshafts and cylinder-walls, but not yet on a production basis. Recently, said Mr. Kilduff, a company in Boston ran a chromium-plated shaft on a babbitt bearing at 17,000 r.p.m., using water as a lubricant, and, although a side-thrust of 100 lb. was applied, no appreciable heat was developed during several hours.

For the great saving that has been effected in labor required to maintain the appearance of plated parts of automobiles, credit for developing the chromium-plating process to its present commercial stage was given by the author to the General Motors Corp., United Chromium, Elwood Haynes and the Bureau of Standards. As it becomes further developed, a still greater saving will result from the elimination of wear on moving parts, thereby increasing the normal life of the car three to five times.

Finish Makers Welcome Challenge

Ten years ago, when old-fashioned paint and varnish finish was applied to automobiles, the bright nickel parts made the rest of the car look shabby after it had been used through one summer or for 9 or 10 months, said Mr. Given, the second speaker. When the new Duco pyroxylin finish put out in 1923 or 1924 was applied, the car finish stood up about the same as the nickel, so that all parts of the car grew shabby at about the same rate. In more recent years, the nickeling began to tarnish and look old before the rest of the

body. Now, with chromium-plating, the speaker said he supposes the body finish again will show age first. However, competition makes the world progress, and the finish makers welcome the challenge of the platers.

A sidelight on the origin of pyroxylin finish was given by Mr. Given when he said that some bright man in California, where hot sand and alkali dust are too plentiful for the good of cars, conceived the idea of applying to the car the pyroxylin lacquer that was used 30 or 40 years ago on house-lamp fixtures. It proved a success, although the job cost $300 or $400, which was no object to the people around Hollywood. This started the duPont company on an investigation that led to the development of Duco.

After showing lantern slides depicting the changes that occurred in paint and varnish finishes and the long series of tests of pyroxylin finishes by exposure of thousands of panels in New Jersey and Florida, Mr. Given described the process of making Duco finish. Three types of nitrocellulose are now on the market and in use by manufacturers of automobiles. One process of preparing the concentrated product is by heat-treatment under pressure. After 20 min. of heating at 120 deg. cent. (248 deg. fahr.), the viscosity is reduced to 8 per cent of the former viscosity. Another method of arriving at the same result is by introducing an alkali and, after a time, neutralizing the material. By this process, the viscosity is lowered to 7 per cent in 12 min.

Very few natural materials are used, continued Mr. Given, the nitrocellulose being a synthetic product of cotton stripped from the seeds after ginning. The other ingredients are liquids that also are synthetic, such as banana oil and a fusel-oil substitute produced by the action on grain meal of the nice little French product, acetylethyleneglycolmonoethylether.

Difficult To Match Tints

One of the most difficult operations is to match colors, which cannot be controlled scientifically, although chemists and chemical and optical engineers have struggled for years to find a means equal to the human eye for measuring color. With 3000 to 4000 colors and tints, the matching of them is a serious problem in the manufacture of Duco.

The maker does not know whether a certain batch is to be used on a body, a hood or to refinish a top. The importance of exact matching of the tint was indicated by the speaker by citing a case of a batch being ordered from Parlin, N. J., for use on a body built in Massachusetts to be mounted on a chassis built in Michigan and finished with Duco bought in Flint, Mich. Tints are compared on wet plates in laboratory darkroooms under ultra-violet, mercury and two other types of light, the plates being examined one against another.

Varied uses of pyroxylin finishes in the industries were mentioned, including the furniture, toy, refrigerator, linoleum and kitchenware industries.

As a production material, the advantage of pyroxylin finish was made impressive by comparing the time of seven to nine days required to finish a body with varnish and the two days needed with Duco; the 170 men required to finish 125 bodies daily with varnish against 150 men to finish 300 bodies with Duco; and the space required for 2400 bodies in process with varnish against 600 in process with the new finish for the same daily production.

The paper was brought to a conclusion by a warning against fire hazard and some demonstrations of dust explosions with a light dust having about the composition of ordinary starch.

Extended and interesting discussion followed the presentation of the two papers, many questions being asked of and answered by each speaker. An interesting sidelight was revealed when Glenn S. Whitham told of the effect that chromium-plating and pyroxylin finishes have had on the garage business. Because chromium-plating has greatly reduced the amount of work where full service is given to keep cars looking clean and fresh, the garage is enabled to make a lower rate to the owner. On the other hand, cars finished with pyroxylin do not need such frequent washing and polishing as painted and varnished cars, hence the garage does not get so much trade. Thus, as Mr. Given remarked, in one case the garage cut the price and lost the business, and, in the other case, it just lost business.

Northwest Section Formed

Seattle Organization Meeting Attended by 170 from Four States and British Columbia

FORMAL organization of the Northwest Section of the Society was effected at a meeting on Dec. 15 at the New Washington Hotel in Seattle following a banquet. Among the 170 in attendance were automotive men from various parts of the States of Washington, Oregon, Idaho, and California and from British Columbia, and also representatives of the Seattle Chamber of Commerce, the Automobile Club, the Automobile Dealers Association and civic officials. Fourteen members traveled 200 miles to get to the meeting, and George C. McMullen presented greetings from the Society and from the Northern California Section. The entire press of the city was represented also.

Robert S. Taylor, of Seattle, presided and was later nominated for Chairman. Ethelbert Favary, of the Southern California Section, represented the National Society and was the principal speaker of the evening. He formally declared the Northwest Section in existence, and explained about methods of securing papers for meetings, the treasurer's account, and so forth.

The lusty new Section in the Society's family starts life with a membership of 107, representing the foremost automobile and aeronautic technical men of the Northwest corner of the United States.

In addition to Robert S. Taylor for Chairman, officers were nominated as follows, to be elected by letter-ballot:

Prof. F. G. Baender, of Oregon State College, First Vice-Chairman

Valentine Gephart, of the Valentine Co., Seattle; A. R. Trombly, of Portland, Ore.; Earl B. Staley, of Seattle; and Donald F. Gilmore, of Seattle, all Second Vice-Chairmen

A. M. Jones, of the Willis-Jones Machinery Co., of Seattle, Secretary

George Morrissey, of Seattle, Treasurer.

All of the members are pulling together with an excellent spirit and enthusiasm, and a good job of organizing was done.

Oil Contamination Removal

MAINTENANCE of Automobile Crankcase Oil by Means of Filters was the subject of a paper presented by A. F. Weston, of the Motor Improvement Corp., of Newark, N. J., at the Dec. 18 meeting of the Buffalo Section. He dealt with the physical and chemical changes of the oil resulting from contamination by foreign particles, its dilution by unburned fuel, and the formation of sludge resulting from water condensation. Then he told of means of removing the impurities by filtering in the engine, and of tests of filters on cars operated in Texas and from the Atlantic to the Pacific coast and return. In conclusion he mentioned the installation of oil-filters with divided-stream connection and regulating means to control the amount of oil passing through the filter and also to maintain the pressure across the filter at or below a predetermined value. Another means mentioned of guarding against insufficient lubrication in event of the filter becoming clogged is to install an automatic by-pass valve that opens when the filter becomes clogged.

A great deal of discussion followed

the presentation of the paper, consisting largely of questions intended to elicit more detailed information on many points, and of specific answers given by Mr. Weston.

Forty-one members of the Section were in attendance, and William Edgar John, treasurer of the Section, acted as chairman in the absence of chairman E. W. Kimball.

A Meeting on Springs

NORTHERN California Section members gathered at the Engineers Club in San Francisco on the evening of Dec. 13 to have dinner together and to hear Prof. Arthur B. Domonoske, executive head of the mechanical engineering department of Stanford University, give an address on the Design and Characteristics of Automotive Springs. Chairman S. B. Shaw presided.

Grahame B. Ridley was elected as alternate to represent the Section on the Society's Nominating Committee. Chairman Shaw then showed a diagram of the Reorganization Chart as published in the December number of the S.A.E. JOURNAL and explained the proposal of the Reorganization Committee, following which there was some discussion of the plan. Upon bringing the subject to a close, Chairman Shaw said that the set-up as shown by the chart is better for the Western Sections than the present organization of the Society because it recognizes Operation and Maintenance and Aeronautic activities, and announced that the Northern California Section is nearly ready to start an Aeronautic Division, on the paper organization of which some work has been done.

Professor Domonoske's address dealt with helical and cantilever springs and was of a technical nature, containing algebraic formulas of vibration periods, weight computation, stresses, stored energy, and so on. He illustrated many points by drawing on the blackboard, told how the making of springs should be specified, and spoke about damping.

Numerous questions were asked by members in the discussion and answered by the speaker.

Operation and Maintenance

(*Concluded from p.* 89)

training-school graduates. It would be important to provide a means for checking the school's course, or the graduates could be examined and certified at suitably distributed points throughout the Country. This is not to be confused with the licensing of mechanics such as might be brought about by State laws, which, experience in other lines indicates, is dangerous and leads almost inevitably to unionizing of shops. The automobile industry so far has been almost exclusively open-shop, to the great advantage of employers, employes and the public.

There are five types of school to be considered; commercial, semi-endowed, public, endowed, and company-owned schools. Commercial schools are those which will give what the student will buy. Endowed, semi-endowed, public and company-owned schools give what the student should have. The object of the Committee should be to try to devise a training course which will be acceptable for all five classifications.

Recommendations

It is recommended that the shopwork of the course be handled on a cooperative basis with service stations. An arrangement could be worked out whereby a student would work alternately in the service station and in the school shop. This would give the student an opportunity to get specialized training on the car he intends to work on after graduation, and would allow the service station to see whether he was worth hiring. The school would not graduate the man unless, in his shopwork, he showed that he was likely to become a good mechanic.

Replies to a questionnaire sent to fleet operators and service stations indicated that courses could be improved by giving the men more practical training in the use of tools.

It is earnestly recommended that the possibilities of all of the above suggestions be thoroughly investigated by a committee appointed by the Society of Automotive Engineers to determine the advisability of the Society's engaging in some concrete effort to increase the available supply of competent help in automotive repair-shops. It seems to this Subcommittee to be an undertaking entirely within the proper functions of the Society.

Acknowledgment is made of the valuable assistance given by H. R. Cobleigh, of the National Automobile Chamber of Commerce; Louis Credner, of the West Side Y. M. C. A. Automobile School; T. R. Lomer, of the White Co.; J. J. Percivall, of the Gulf Refining Co.; and others.

F. L. JACOBUS for T. L. PREBLE,
Chairman.

Important Operation Papers

INFORMATION valuable to readers specially interested in operation and maintenance appears in several papers printed elsewhere in this issue. Fleet-Superintendent Qualifications are discussed in the paper by Donald Blanchard, editor of *Operation and Maintenance*, beginning on p. 52. The operating methods of the Yelloway-Pioneer Stages, Inc., in maintaining transcontinental motorcoach-service between Pacific Coast cities and New York City are outlined in the paper by W. E. Travis which begins on p. 61.

T. H. MacDonald, chief of the Bureau of Public Roads, Department of Agriculture, City of Washington, deals with the Effect of Six-Wheel Vehicles on Highway Design in the paper that begins on p. 41. The discussion of the paper by Ethelbert Favary on Highway Legislation and the Six-Wheel Truck begins on p. 46, the paper having been published in the December issue of the S.A.E. JOURNAL beginning on p. 605.

Careful perusal of the foregoing papers will be well repaid by the facts they convey and by the stimulating ideas they express.

Personal Notes of the Members

Beecroft Joins Bendix

David Beecroft recently severed his connection of long standing with the Class Journal Co., and later with the Chilton Class Journal Co., to become vice-president of the Bendix Corp., with

DAVID BEECROFT

offices in the Grand Central Terminal, New York City. His editorial career with the Chilton Class Journal Co. dates back to 1904, when he assumed the duties of assistant editor of *Motor Age* in Chicago. Not long afterward he was made editor of that publication, and subsequently became managing editor of the company in New York City, general manager of *Motor Transport* and chairman of the Advisory Committee of the Chilton Class Journal Co. These promotions culminated in his appointment to the vice-presidency of the company in 1926. His early journalistic experience, prior to joining the Class Journal Co., was gained as advertising solicitor for the *Chicago Daily News* and as editor of *The Automobile Review*, a weekly issued in Chicago.

Mr. Beecroft's membership in the Society, which began in 1911, has been characterized by an unfailing interest and cooperation in its activities. He has been a prominent figure in the administration of Society affairs and has held numerous offices. He has been chosen Councilor for five terms, serving as First Vice-President in 1918. In 1921 he was elected President of the Society. For four successive years he held the chairmanship of the National Meetings Committee; in 1922 he was named Society representative on the Advisory Board on Highway Research of the National Research Council; in 1925 he was Chairman of the House Committee, and in 1927 served on the Membership Committee. His enthusiastic support of Society work has been paralleled by a keen interest in Section activities. He joined the Metropolitan Section in 1915 and for a period of three years was a member of both the Detroit and the Metropolitan Sections. This year he is serving as Chairman of the Papers Committee and as a member of the Publication Committee of the Metropolitan Section.

Mr. Beecroft has presented many interesting and illuminating papers at National and Section meetings of the Society. Among these are the following: Society Governmental Activities, published in the April, 1918, issue of THE JOURNAL; The Relation of the Vehicle Builder to Motor Transport, which appeared in the May, 1924, issue of THE JOURNAL; and the Society's Research Program, his Presidential address, delivered at the 1921 Semi-Annual Meeting of the Society, the text of which was printed in THE JOURNAL for July, 1921, and in Part 2 of TRANSACTIONS for that year.

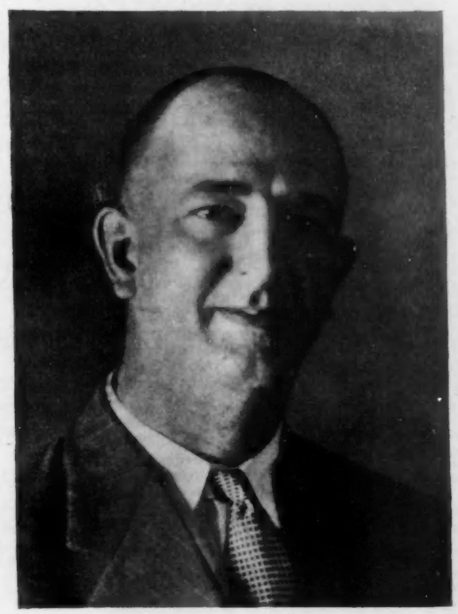
Naylor Chief Engineer for Stout

William C. Naylor, one of the foremost engineers in the aircraft industry, and formerly chief engineer of the Stinson Aircraft Corp., in Northville, Mich., has become associated with the William B. Stout Engineering & Finance Co., at Dearborn, Mich., in the capacity of chief engineer. Mr. Naylor's early engineering experience was obtained in the service of the Packard Motor Car Co., which he joined in 1923 following his graduation from the University of Michigan with the degree of Bachelor of Science in Aeronautical Engineering. He left this position a little less than a year later to engage in drafting and layout work for the Chevrolet Motor Car Co. He next became affiliated with the Aircraft Development Corp. as aeronautical engineer, his work with this company serving as the basis for his remarkably rapid advance in the field of aeronautics. In 1925 he was appointed chief engineer of the Stinson Aircraft Corp., a post which he recently gave up to become identified with William B. Stout's company.

Elected a Junior Member of the Society in 1927, Mr. Naylor became a Detroit Section member the same year. His interest in Society work has naturally centered in the aeronautical activities, and he has taken a leading part in the Society's aeronautical program. Under his able chairmanship, the Commercial Aviation Session of the National Aeronautic Meeting, held in Chicago last month, was one of the most interesting and successful sessions of the meeting. At present Mr. Naylor is serving as Chairman of the Meetings Committee of the Detroit Section Aeronautic Division.

Bouton Forms New Connection

Eugene Bouton, of wide experience in matters of production, has resigned as supervisor of time-study for the Chandler-Cleveland Motors Corp. and is now acting in a similar capacity for the J. I. Case Threshing Machine Co., of Racine, Wis. His engineering apprenticeship was served with the Fairbanks, Morse & Co., which was followed by several years experience in various automobile plants as machinist, toolmaker and department foreman. He returned to The Fairbanks-Morse Co., Sheffield Works, in 1918 and was employed in the time study department. Since then he has devoted his interests to this phase of production and has been successively associated with the International Har-



EUGENE BOUTON

vester Co., Petroleum Motors, the Lexington Motor Car Co., and the Chand-

(*Continued on page* 40)

Applicants Qualified

The following applicants have qualified for admission to the Society between Nov. 10 and Dec. 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

AIERS, ARTHUR JOSEPH (F M) production manager, Riley (Coventry) Ltd., *Coventry, Warwickshire, England;* (mail) Labrador, Glendower Avenue.

BOEHNLEIN, CHARLES (M) assistant professor in mathematics, mechanics, College of Engineers, University of Minnesota, *Minneapolis.*

BURGOINE, ALFRED CHARLES (F M) assistant to chief engineer on production, Bristol Aeroplane Co., Ltd., *Bristol, England;* (mail) 50 Tyndalls Park Road.

BUSEY, ROBERT E. (J) student engineer, Packard Motor Car Co., *Detroit;* (mail) 94 West Ferry Street, Apartment 8.

CAMPBELL, DONALD M. (A) sales engineer, Aluminum Co. of America, 3311 Dunn Road, *Detroit.*

CHANG, KWANG H. (J) student, training as a designer, Packard Motor Car Co., *Detroit;* (mail) 735 Y.M.C.A.

CHAPMAN, GEORGE T. (M) factory engineer, Barnes-Gibson-Raymond, Inc., *Detroit;* (mail) 1375 East Grand Boulevard.

CLARK, SHELDON A. (A) staff engineer, Sinclair Refining Co., 45 Nassau Street, *New York City.*

CURTIS, ROBERT HENRY (M) mechanical superintendent, Robert Simpson Co., Ltd., 176 Yonge Street, *Toronto, Ont., Canada.*

FARAGHER, PAUL V. (M) metallurgist, in charge of specifications and standards, United States Aluminum Co., 2400 Oliver Building, *Pittsburgh.*

FAWCETT, ERLE WHITE (A) general manager, Independent Lubricating Co., *Topeka, Kan.;* (mail) 1209 Boswell Avenue.

FELIX, FRANK CHESTER (A) salesman, industrial department, National Electric Products Corp., 1110 Fulton Building, *Detroit.*

FITZPATRICK, A. W. (A) educational service manager, Hart Parr Co., *Charles City, Iowa;* (mail) 506 Wisconsin Street.

GIBSON, HARRY LAURENCE (J) technical advisor, Scenic Line Airway, *Salt Lake City, Utah;* (mail) 933 East 17 South Street.

GREEN, ROLLAN A. (A) vice-president, general manager, Graham-Paige Co. of England, 1075 Commonwealth Avenue, *Boston.*

GROSSMAN, D. R. (A) vice-president, general manager, Studebaker Corp. of Canada, Ltd., *Walkerville, Ont., Canada.*

HAMILTON, JAMES G. (M) 6778 Chestnut Street, *Mariemont, Ohio.*

HAWK, H. B. (A) resident manager, Valvoline Oil Co., 175 Cottage Street, *Chelsea, Mass.*

HAZARD, JAMES HOWARD (J) student, automotive engineering division, Central High School, City of Washington; (mail) 16 New York Avenue, *Takoma Park, D. C.*

HEADLEY, BRADFORD N., LIEUT. (S M) assistant to chief, motor transport division, Quartermaster Corps, United States Army, *City of Washington;* (mail) Office of the Quartermaster General.

HEDLEY, THOMAS ARTHUR (A) chief instructor, gas engine and tractor department, Provincial Institute of Technology and Art, *Calgary, Alta., Canada.*

HEIMAN, JOHN M. (A) foreman, automotive equipment, Cudahy Packing Co., Los Angeles; (mail) 1029 Rosedale Court, *Glendale, Cal.*

HEUM, ALF (J) draftsman, engineer, Fairchild Airplane Mfg. Corp., *Farmingdale, N. Y.;* (mail) 900 Fulton Street.

HUNT, B. B. (A) maintenance foreman, Union Ice Co., *Oakland, Calif.;* (mail) 2645 Nicol Avenue, East.

INGOLD, GUSTAV (M) service manager, export department, Auburn Automobile Co., *New York City;* (mail) Care Mario Studios, 225 Fifth Avenue.

JENSEN, GUNNAR (M) designer, Walker Mfg. Co., *Racine, Wis.;* (mail) 2020 Taylor Avenue.

JOHNSTON, WILLIAM J. (A) vice-president, Wisconsin Motor Co., Milwaukee; (mail) 908 Lakeside Place, *Chicago.*

KERBY, ROY D. (A) general manager, Durant Motors of Canada, Ltd., Box 220, *Toronto, Ont., Canada.*

KNAPP, THOMAS L. (A) salesman, industrial department, Pennzoil Co., 155 West Washington, *Los Angeles.*

KUBAT, ANTONIN O. (F M) manufacturing manager, Ceskomoravska-Kolben-Kanek, *Prague, Czechoslovakia;* (mail) Vysocany 466.

LAND, EMORY SCOTT, CAPT. (S M) Bureau of Aeronautics, Construction Corps., Navy Department, City of Washington; (mail) Daniel Guggenheim Fund for the Promotion of Aeronautics, 598 Madison Avenue, *New York City.*

LANGER, KONRAD (M) designer, Brooks Steam Motors, Inc., 622 Northumberland Street, *Buffalo.*

LEAMY, ALAN H. (J) body designer, Auburn Automobile Co., *Auburn, Ind.*

LEWIS, OSCAR B. (A) sales representative, Ethyl Gasoline Corp., 25 Broadway, *New York City.*

LINSENMEYER, FRANCIS J. (M) professor of mechanical engineering, University of Detroit, *Detroit.*

LUNDE, OTTO H. (J) aerodynamics and stress analysis, Fairchild Airplane Mfg. Co., Farmingdale, N. Y.; (mail) Box 541, *New Hyde Park, N. Y.*

MARQUIS, A. N. (A) secretary, general manager, A. N. Marquis Co., Oklahoma City, Okla.; (mail) 528 East Washington Street, *Phoenix, Ariz.*

MAZARELLA, RICHARD L. (J) designer, American Telephone & Telegraph Co., New York City; (mail) 1280 Herkimer Street, *Brooklyn, N. Y.*

MCWHIRTER, L. D. (A) engine mechanic, L. C. Buxton, 1535 West 37th Place, *Los Angeles.*

MILLER, DAVID R. (A) proprietor, Miller's Brake Service, 367 Park Avenue, *Worcester, Mass.*

MORGAN, LAWRENCE A. (A) service man, Buda Co., Harvey, Ill.; (mail) Box 1159, *Tulsa, Okla.*

NEUNER, FRED W. C. (A) chief engineer, Indiana Lamp Division, Allied Products Corp., *Connersville, Ind.;* (mail) 124 Ninth Street, West.

OAK, PHILIP T. (J) research engineer, engine laboratory, Standard Oil Co. of Indiana, Front Street, *Whiting, Ind.*

PENNEBAKER, R. H. (M) lubricating engineer, Standard Oil Co. of Louisiana, *New Orleans.*

PLACE, ALFRED W. (M) vice-president in charge of engineering and sales, Universal Machine Co., Pike Street, *Bowling Green, Ohio.*

PORTIER, R. E. (A) chief mechanic, Union Ice Co., 660 South Alameda Street, *Los Angeles.*

POSNER, SAMUEL (A) secretary, chief engineer, Posner Brake Lining Service, Inc., Newark, N. J.; (mail) 8 Ingram Street, *Yonkers, N. Y.*

RANDLES, JOHN THOMAS TURNEY (M) works director, (Fort Dunlop), Dunlop Rubber Co., Ltd., *Fort Dunlop, Birmingham, England.*

RAWLS, S. W. (A) gas and oil distributor, Rawls Garage, *Franklin, Va.*

REED, HAROLD E. (M) layout, design, chassis engineering, American Car & Foundry Motors Co., 5718 Russell Street, *Detroit.*

REID, HENRY J. E. (S M) engineer in charge, research laboratory, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

REISNER, J. HENRY (J) assistant production superintendent, Kreider Reisner Aircraft Co., *Hagerstown, Md.;* (mail) 24 Bellevue Avenue.

ROBB, JAMES C. (A) manager new department, J. G. Brill Co., *Philadelphia;* (mail) The Fairfax, 43rd and Locust Streets.

ROBE, WALTON BURDETT (M) vice-president, metallurgist, Egal Metal Products Co., Baltimore; (mail) 27 West Pennsylvania Avenue, *Towson, Md.*

SEIBERT, RICHARD W. (A) foreman repairs, automotive equipment, Texas Co., Long Island City, N. Y.; (mail) 610 Bedford Avenue, *Bellmore, N. Y.*

SPAL, EDWARD C. (J) spring engineer, William D. Gibson Co., Chicago; (mail) 1917 South Bunderson Avenue, *Berwyn, Ill.*

STEVENS, LOUIS W. (M) superintendent, Hartford plant, Veeder-Root, Inc., *Hartford, Conn.*

THONGER, JOHN ROBERT (M) experimental engineer, Le Roi Co., *Milwaukee;* (mail) 3311 Wells Street.

TREPTOW, HERMAN (A) service manager, Packard Motor Sales Corp., *New Brunswick, N. J.;* (mail) 43 Delaven Street.

UNDERWOOD, ARTHUR J. (M) technical test assistant, Chevrolet Motor Co., *Detroit;* (mail) 1205 Collingwood Avenue.

WALLACE, HIRAM LEW (M) research, tractor testing engineer, agricultural engineering department, University of Nebraska, *Lincoln, Neb.*

WERRA, JULIUS W. (M) general superintendent, Werra Aluminum Foundry Co., *Waukesha, Wis.;* (mail) 203 East Avenue.

WEST, ROLAND A. (A) instructor in automobile mechanics, Tilden Technical High School, Board of Education, *City of Chicago;* (mail) 6420 Sangamon Street.

WILLIAMS, EDWARD GEORGE (A) export counsel, Franklin Automobile Co., *Syracuse, N. Y.*

WISE, RALPH H. (J) draftsman, International Harvester Co., *Springfield, Ohio;* (mail) 116 Lincoln Avenue.

WOYDT, EDWARD (M) mechanical engineer, White Motor Co., *Cleveland;* (mail) 10120 Wilbur Avenue.

Applicants for Membership

The applications for membership received between Nov. 15 and Dec. 15, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ABERT, HAMILTON, assistant factory manager, Manhattan Rubber Mfg. Co., *Passaic, N. J.*

ADAMS, ARTHUR A., member board of directors, National Aircraft Industries, Aviatrest, *Moscow, U. S. S. R.*

ALLEN, GEORGE FRANKLIN, vice-president and general manager, Hoyt Metal Co. of Canada, Ltd., *Toronto, Ont., Canada.*

ARBOUR, EVERETT J., partner, Joseph Arbour & Son, *New Britain, Conn.*

AVERILL, FRANK B., factory manager, Durant Motors of Canada, *Leaside, Ont., Canada.*

BARRETT, DANIEL J., JR., secretary and general manager, Barrett Airways, Inc., *Armonk, N. Y.*

BATEMAN, ARTHUR T., chief engineer, Bohnalite Products Division, Bohn Aluminum & Brass Corp., *Detroit.*

BEATON, JOHN H., general sales manager, General Motors of Canada, *Oshawa, Ont., Canada.*

BENNETT, CLAUDE C., secretary, treasurer, A. E. Feragen, Inc., *Seattle, Wash.*

BLAIR, DAVID EDWARD, general superintendent, Montreal Tramways Co., *Montreal, Que., Canada.*

BLAKE, EDWARD C., president, Blake Motor Car Co., *New Rochelle, N. Y.*

BOUSMAN, NUGENT, mechanic, in charge of engines, Universal Air Lines, *Chicago.*

BRANAN, FURNIE CASWELL, instructor, Nashville Automobile School, *Nashville, Tenn.*

BUDD, ROBERT WILLIS, manager of operations, Northland Transportation Co., *Minneapolis.*

CABENA, HAROLD, service manager, Queen's Bridge Motors Proprietary, Ltd., *South Melbourne, Australia.*

CAIN, DAVID A., lubricating engineer, aviation, Union Oil Co. of California, *Los Angeles.*

CARRON, IRIS, body layout draftsman, Chrysler Corp., *Detroit.*

CARSON, WILLIAM L., superintendent of machine shops, Washington Iron Works, *Seattle, Wash.*

CELECIO, FLORENTINO P., 133 Bowne Avenue, *Flushing, N. Y.*

CHAILLOT, RENE, mechanical engineer, Michelin Tire Co., *Milltown, N. J.*

CHILDS, STERRY HUNT, vice-president and general manager, Hendey Machine Co., *Torrington, Conn.*

CHURCH, HAROLD B., treasurer, H. B. Church Truck Service Co., *Roxbury, Mass.*

CLARK, H. HOY, engineer, Cleveland Wire Spring Co., *Cleveland.*

COLEMAN, WILLIAM R., shop foreman, Standard Oil Co., *Seattle, Wash.*

COMBER, FRANCIS WILLIAM, supervisor of motor vehicles, Bell Telephone Co. of Pennsylvania, *Philadelphia.*

CORDICK, ROBERT JAMES, service manager, General Motors Products, Ltd., *Oshawa, Ont., Canada.*

COTTRELL, JAMES W., technical editor, *Commercial Car Journal*, Chilton Class Journal Co., *Philadelphia.*

DART, EDWARD W., assistant engineer, Metal Aircraft Corp., *Cincinnati.*

DE CAMP, ROBERT BENJAMIN, superintendent of maintenance, De Camp Bus Lines, *Livingston, N. J.*

DENVIR, JAMES P., special representative, fleet and national accounts, Reo Motor Car Co. of New York, Inc., *New York City.*

DIETER, WILLIAM, torpedo engineer, E. W. Bliss Co., *Brooklyn, N. Y.*

DIETERICHS, FRANK FRED, assistant chief inspector, John Warren Watson Co., *Philadelphia.*

DIMM, IRA LLOYD, manager, exchange car department, Rolls-Royce of America, Inc., *New York City.*

DITCHBURN, HERBERT, president and manager, Ditchburn Boats, Ltd., *Cravenhurst, Ont., Canada.*

DOUGLAS, EARL C., vice-president, A. E. Feragen, Inc., *Seattle, Wash.*

DRESSER, WILFRED C., service manager, Capitol Buick Co., *Hartford, Conn.*

DREW, GARVIN, A. Schrader's Son, Inc., *Detroit.*

DUNNIGAN, M. A., engineer, D. H. Barker Co., *Minneapolis.*

ENGELHARDT, PAUL, general manager, Rochet-Schneider, *Lyons, France.*

EVANS, LLYWELYN CHARLES, research engineer, Perfex Corp., *Milwaukee.*

FERGUSON, ALEXANDER DALE, assistant engineer, Bureau of Economics, Canadian National Railways, *Montreal, Que., Canada.*

FERGUSON, ARCHIBALD, chief draftsman, Ricardo & Co. (1927), Ltd., *Sussex, England.*

FREY, GEORGE, general sales manager, The J. G. Brill Co., *Philadelphia.*

FREY, WILLIAM F., instructor of aeronautics, West Side Continuation School, *New York City.*

GARNER, GEORGE WESLEY, specification engineer, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

GLENN, CHARLES, foreman, Willys-Overland Co., *Toronto, Ont., Canada.*

GUYNN, ADAM D., service manager, Rock Island Implement Co., *Kansas City, Mo.*

HARTMAN, WILLIAM L., tool designer, International Harvester Co., *Fort Wayne, Ind.*

HATCH, I. N., service manager, Stutz Motor Car Co., *Chicago.*

HENNING, OTTO, sales engineer, Carter Carburetor Corp., *St. Louis.*

HERFURTH, WALTER R., assistant traffic manager, Freihofer Baking Co., *Philadelphia.*

HOLDER, HERBERT ROGER, superintendent auto-bus garage, Montreal Tramways Co., *Montreal, Que., Canada.*

HOLMES, E. W., president, Ernest Holmes Co., *Chattanooga, Tenn.*

HOPKINS, GEORGE D., president, Hopkins Mfg. Co., *Hanover, Pa.*

HUBBARD, GUY, advertising manager, National Acme Co., *Cleveland.*

IRVINE, ANDREW, superintendent machine-shop and pattern division, Bohn Aluminum & Brass Corp., *Detroit.*

JANEWAY, ROBERT N., consulting engineer, 9028 Dexter Boulevard, *Detroit.*

KENNEDY, EUGENE J., executive instructor, automotive and battery department, Coyne Electrical School, *Chicago.*

LAIRD, A. WILSON, designer, American La-France & Foamite Corp., *Elmira, N. Y.*

LAPHAM, RAY S., assistant technical service manager, The White Co., *Cleveland.*

LESLIE, JOHN C., assistant in Mr. Fokker's office, Fokker Aircraft Corp. of America, *Hasbrouck Heights, N. J.*

LINCOLN, DON, general manager, Python Grip Brake & Equipment Co., *Los Angeles.*

LIVINGSTON, WILLIAM M., superintendent motor-vehicles, Town of Montclair, *Montclair, N. J.*

LUND, J. KENNETH, assistant engineer, Dole Valve Co., *Chicago.*

MACFARLAND, ROY H., technical service roadman, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

MACKENZIE, A. K., service manager, Massy, Ltd., *Port-of-Spain, Trinidad, British West Indies.*

MIVILLE, AUGUSTINE C., proprietor, Toronto Brake Service, *Toronto, Ont., Canada.*

MOREHOUSE, WILBUR RAYMOND, service manager, Morehouse Baking Co., *Lawrence, Mass.*

PARK, W. GORDON, superintendent military plant, Kelsey-Hayes Wheel Co., *Detroit.*

PARKER, A. L., owner, Parker Appliance Co., *Cleveland.*

PLUMLEY, BURTON S., sales engineer, Aluminum Industries, Inc., *Cincinnati.*

POND, LIEUT. GEORGE R., U. S. N. (Fleet Reserve), *City of Washington.*

PONTI, COLUMBUS F., electrical engineer, International Motor Co., *Long Island City, N. Y.*

POWELL, H. EMERSON, JR., instructor in automobile mechanics, senior high school, Board of Education, *South Orange, N. J.*

PURVIS, GEORGE H., technical field supervisor, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

QUIGLEY, JOHN MILTON, draftsman, designer, Marion Motors, Inc., *Marion, Ohio.*

RADERMACHER, LAWRENCE J., chief engineer, Kempsmith Mfg. Co., *Milwaukee.*

RICE, CHARLES M., JR., 9 Bowdoin Street, *Worcester, Mass.*

RICKERT, HAROLD T., assistant to general manager, motor transport department, Pure Oil Co., *Chicago.*

ROSHIRT, RANDOLPH J., manager, Bohn Aluminum & Brass Corp., *Detroit.*

SAYERS, W. G., factory superintendent, Willys-Overland, Ltd., *West Toronto, Ont., Canada.*

SCHRAGG, T. F., bearing application, automotive, Timken Roller Bearing Co., *Canton, Ohio.*

SHAFER, R. V., service manager, Harnischfeger Sales Corp., *San Francisco.*

SHEPPARD, A. G., designing engineer, American-LaFrance & Foamite Corp., *Elmira, N. Y.*

SMITH, ADELBERT RAY, on manufacturing staff, Chrysler Corp., *Detroit.*

SMITH, JAMES L., superintendent motor-coach department, Toronto Transportation Commission, *Toronto, Ont., Canada.*

SOMERVILLE, GEORGE N., manager, engineer, industrial division, Atlas Imperial Diesel Engine Co., *Oakland, Cal.*

STREYFFERT, M. J., assistant factory superintendent, Willys-Overland, Ltd., *Toronto, Ont., Canada.*

SUBASKY, machine designer, Poole Engineering & Machine Co., *Baltimore.*

TAYLOR, WILLIAM E., experimental test department, International Motor Co., *Allentown, Pa.*

TELLER, LOUIS K., superintendent of maintenance division, Rubel Coal & Ice Co., *Brooklyn, N. Y.*

THEDGAR, VICTOR L., draftsman, Hupp Motor Car Corp., *Detroit.*

THOMSON, J. E., manufacturers' representative, Firestone Tire & Rubber Co., *Akron, Ohio.*

TINGER, MICHAEL, JR., shop foreman, Lawson Lynch Co., *Royal Oak, Mich.*

TITTENSOR, PERCY, experimental engineer, A. C. Spark Plug Co., *Flint, Mich.*

ULLIMAN, EDWARD A., master-mechanic foreman, Superior Engine Co., *Springfield, Ohio.*

VERENTENNICOFF, VLADIMAR A., engineer, General Motors Continental S. A., *Antwerp, Belgium.*

WATKINS, LEO R., salesman commercial accounts, United States Rubber Co., *Seattle, Wash.*

WEINGARDEN, NATHAN, assistant chief draftsman, chassis, Oakland Motor Car Co., *Pontiac, Mich.*

WHITTAKER, RICHARD S., chemist, Universal Products Co., *Fordson, Mich.*

Notes and Reviews

AIRCRAFT

The Variation in Pressures in the Cockpit of an Airplane in Flight. Technical Note No. 300. By Thomas Carroll and William H. McAvoy. Published by the National Advisory Committee for Aeronautics, City of Washington, 6 pp.; illustrated. [A-1]

The investigation reported in this Note was undertaken to provide information concerning the variation in pressure within the fuselage of an airplane which might produce erroneous indication by instruments, particularly the altimeters. The airplane used was a Vought VE-7, which is of open-cockpit type with normal windshields installed on each of the two cockpits. The airplane was flown through a series of speeds from 60 to 120 m.p.h. in the condition of level flight and of climb. To determine the effect of altitude, observations were made in corresponding flights at altitudes of 1000 and 10,000 ft. The observed values were in general small and the effect upon the instruments inconsiderable.

Structural Analysis and Design in Relation to Commercial Aviation Safety. By T. P. Wright. Paper presented before the Seventeenth Annual Safety Congress, New York City, Oct. 1-5, 1928. [A-1]

In the opinion of the author the most important single factor which can convince the public of the possibilities of the airplane as an every-day carrier of men and goods is assurance of safety comparable with that existing in other means of transportation. The types of danger that now exist in aviation are outlined, the general theory of the factor of safety in airplane design is discussed and the distinction between load factor and real factor of safety explained. The paper also covers the methods of obtaining load factors, stress analyses, and the relation of materials used in airplane structure to stress analyses.

Summing up the main sources of improvement that can be expected in the future, which will make aviation safer as regards structural integrity, the author names four: (*a*) coordination of aerodynamics and stress analysis, (*b*) more general use of static testing (*c*) application of sound engineering in the design of fittings, and (*d*) the supplying by our universities of aeronautical engineers better grounded in the basic principles of structural design and analysis.

The following papers presented at the Safety Congress also are worthy of note:

The Flight Characteristics of an Airplane from a Safety Point of View. By Thomas Carroll.

Commercial Airplane — Structural Reliability from the Operator's Point of View. By Wesley L. Smith.

Inspection of Airplane Structures and Materials in Construction and Operation. By Edward P. Howard.

Fire Prevention in Modern Airplanes and Recent Experimentation. By Capt. O. P. Echols.

Aeronautical Lighting as an Aid to Safety. By F. C. Hingsburg.

Safety of Passengers. By Major R. H. Mayo.

The Parachute in Passenger Flying. By E. L. Hoffman.

Directional Radio as an Aid to Safe Flying. By Dr. J. H. Dellinger.

Organization of Weather Service for Safe Flying on an Airway. By Dr. Carl B. Rossby.

Meteorology as an Aid to Safe Flying. By Willis Ray Gregg.

Outstanding Requirements for Safety in Airships. By Lieut-Commander Herbert V. Wiley.

Control of Aircraft in Air-Transport Service. By Paul Henderson.

Inspection and Maintenance in Air Transport. By Major C. C. Moseley.

Operation of Aerodrome from Safety Point of View. By Major L. F. Richard.

Designing Safe and Adequate Airports. By Harry H. Blee.

Marking of the Airway. By Woody Hockaday.

Airport Operation from a Safety Point of View. By Major John Berry.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J. Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

Drag of C-Class Airship Hulls of Various Fineness Ratios. Report No. 291. By A. F. Zahm, R. H. Smith, and F. A. Louden. Published by the National Advisory Committee for Aeronautics, City of Washington, 16 pp.; illustrated. [A-1]

This report presents the results of wind-tunnel tests on eight C-class airship hulls having various fineness ratios, conducted in the Navy Aerodynamic Laboratory, City of Washington. The purpose of the tests was to determine the variation of resistance with fineness ratio, and also to find the pressure and friction elements of the total drag for the model having the least shape-coefficient.

Seven C-class airship hulls with fineness ratios of 1.0, 1.5, 2.0, 3.0, 6.0, 8.0, and 10.0 were made and verified. These models and also the previously constructed original C-class hull, whose fineness ratio is 4.62, were then tested in the 8 x 8-ft. tunnel for drag at 0 deg. pitch and yaw, at various wind speeds. The original hull, which was found to have the least shape-coefficient, was then tested for pressure distribution over the surface at various wind speeds.

Drag and Cooling with Various Forms of Cowling for a Whirlwind Engine in a Cabin Fuselage. Technical Note No. 301. By Fred E. Weick. Published by the National Advisory Committee for Aeronautics, City of Washington, 25 pp.; illustrated. [A-1]

At the conference of aircraft manufacturers held at Langley Field on May 24, 1927, several requests were made that an investigation of the cowling and cooling problem in regard to radial air-cooled engines be undertaken in the new full-scale propeller-research tunnel which was then being completed. A program for a series of tests was drawn up and submitted to the manufacturers for criticisms and suggestions, several of which were adopted. As finally arranged, the program includes 10 main forms of cowling to be tested on a J-5 engine in connection with two fuselages, three of the former being on an open cockpit fuselage and seven on a closed cabin type. The tests will take considerable time owing to the extensive structural changes on the various cowlings between tests. This report covers in a preliminary way the portion of the investigation involving the cabin fuselage; a complete report will follow.

The cowlings reported in these tests varied from the one extreme of an entirely exposed engine to the other in which the engine was entirely enclosed. Cooling tests were made and each cowling modified, if necessary, until the engine cooled approximately as satisfactorily as when it was entirely exposed. Drag tests were then

(*Continued on next left-hand page*)


KERITE
Another Year added to the performance record of KERITE
THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO
1860
1870
1880
1890
1900
1910
1920
KERITE INSULATED WIRE & CABLE CO
1929
1929

Notes and Reviews

Continued

made with each form of cowling, and the effect of the cowling on the propulsive efficiency with a metal propeller was determined.

Der Fleugzeugbau auf der Ila. By Dr. Ing. v. Langsdorff. Published in *Illustrierte Flug-Woche*, No. 10, 1928, p. 284. [A-1]

While hailing as an achievement the first international aircraft show held at Berlin, the Internationale Luftfahrt-Ausstellung or Ila, the author expresses regret that aircraft manufacturers, especially those of other countries, did not take sufficient advantage of the opportunity to show their products, and to show them in such a way as to interest the public. In general, the models were not wisely selected or well exhibited, information about their performance was lacking or scanty, and the personnel at the stands was not such as to aid the understanding of the lay visitor.

Especially regrettable, in the opinion of the author, was the failure of Holland and America to exhibit any actual airplanes, the participation of these two countries being confined to pictures and models. Of more than 50 airplanes shown, 32 were provided by German manufacturers; 5 each by Italian, Russian and Czechoslovakian; 4 by French, 2 by English and 1 by Belgian builders. According to usage intended, the models fell into the following classes: transport, 14; training, 15; sport, 14; special, 3; not designated, 6. Monoplane types accounted for 32 of the exhibits, and all except 6 were single-engined.

A table is given showing the major specifications of the airplanes exhibited, and brief descriptions of them are included in the article.

CHASSIS PARTS

Progress Report No. 4 of the A.S.M.E. Special Research Committee on Mechanical Springs. By M. F. Sayre and Anthony Hoadley. Paper presented at the Annual Meeting of the American Society of Mechanical Engineers, New York City, Dec. 3 to 7, 1928. [C-1]

This report covers the first year of investigations carried on by the Committee at Union College, Schenectady, N. Y. The purpose of these investigations is to examine more closely than heretofore the fundamental characteristics of spring action so that more reliable constants for a code of design on mechanical springs may ultimately be established.

Points of particular interest are: (*a*) a study of the distribution of stresses in spring steel during bending at the very high unit-stresses often used in practice; (*b*) a comparison of proportional limit and of modulus of elasticity for the same material in bending and in tension at high and at low stresses, both in virgin condition and after the cyclical state has been reached; (*c*) a study of the comparative internal friction in spring material in bending and in tension, for varying stress ranges up to very high loads.

The Efficiency, Strength, and Durability of Spur Gears, Part II—A New Type of Gear-Testing Machine. By William H. Rasche and J. F. Downie Smith. Engineering Experiment Station Bulletin No. 4, Virginia Polytechnic Institute, Blacksburg, Va., 27 pp. [C-1]

The research with which this bulletin is concerned is the second part of a comprehensive investigation of the laws which control the flow of energy through a functioning spur-gear mechanism and of the forces which arise at the teeth and at the bearings. To make possible the accurate testing of friction losses at the teeth and at the bearings, and to determine the static and dynamic loads on the teeth, Mr. Rasche invented the machine described and shown by a set of large detail drawings. It embodies the Webb principle of energy conservation.

(*Continued on next left-hand page*)

Notes and Reviews

Continued

ENGINES

Effects of Multiple Ignition on the Performance of a Small Engine. By H. M. Jacklin. Engineering Experiment Station Bulletin No. 45, Ohio State University, Columbus, Ohio, 20 pp. [E-1]

By the use of multiple ignition and lean mixtures, a saving in fuel consumption of as much as 23 per cent over single-plug ignition is reported by Professor Jacklin. The object of the investigation was to find some of the various effects of the use of several points of ignition in a rather small (2½ x 5-in.) air-cooled gasoline engine.

The Jacklin high-speed indicator had been developed and was available to obtain the indicated horsepower, enabling a study to be made of the effects of multiple ignition and of changes in the mixture ratio on the friction of the engine. Test runs were made with several selected combinations of spark-plugs, with ignition occurring at 10, 20, 30, and 40 deg. advance, and with air-fuel ratios varying from 10 to 1 to slightly more than 18 to 1. The compression used gave no opportunity to observe the effects of multiple ignition on detonation, although certain conclusions may be drawn in this regard. All of this investigation was confined to full-load operation and all runs were made with a cylinder-head giving a compression ratio of 3.65.

In the conclusion, the author states that, while two-point ignition will add somewhat to the cost of an engine of the ordinary automotive size, it is justified because of the probable gain of 4 to 10 per cent in power and the generally smoother operation, especially with lean mixtures. Use of two-point ignition also presents an opportunity to reduce the fuel consumption for a given power by making it possible to use lean mixtures without sacrificing smooth, regular operation.

Stand der Verwendung von Schwerölen in Schnellaufenden Ortsbeweglichen Motoren. By W. Riehm. Paper presented at the Fuel Conference, World Power Conference, London, Sept. 24 to Oct. 6, 1928. English translation appended. [E-1]

Dr. Riehm's paper covers the properties and characteristics of oils suitable for use in high-speed Diesel engines, and the various types of high-speed Diesels, such as compressed-air-injection engines, solid-injection engines, auxiliary-chamber engines and the Acro engine are described in some detail. A survey of present applications of the high-speed Diesel engine in ships, trucks, omnibuses, rail-cars and locomotives is also given.

The Transactions of the Fuel Conference, World Power Conference, will be available early in January from Percy Lund, Humphries & Co., Ltd., The Country Press, Bradford, England, at a special pre-publication price of £10.

Oil Engines for Aircraft and Railways. By A. E. L. Chorlton. Published in *Engineering*, Sept. 21, 1928, p. 375. [E-1]

This paper was presented before the G Section of the British Association at Glasgow, its main purpose being to set forth what had been done, particularly in that district, with regard to the development of oil engines for aircraft and for railway work. It is a full report of the research work done on and practical applications made of various types of oil engine. The conclusion of the article appeared in the Oct. 5, 1928, issue of *Engineering*.

Les Compresseurs M. Z. et la Vouture de Tourisme. By René Charles-Faroux. Published in *La Vie Automobile*, Oct. 10, 1928, p. 565. [E-1]

Unlike racing-engine superchargers which are called into operation only at high engine-speeds and are designed to increase those speeds, the M. Z. supercharger is effective

(*Continued on next left-hand page*)

Notes and Reviews

Continued

only at low engine-speeds and is intended to increase the torque in slow running. It is adapted for use with four-cylinder engines of 61 to 90-cu.-in. capacity, a combination which the inventor believes will provide the automobile operator with the engine flexibility he desires at a lower first cost and fuel consumption than are possible with a six-cylinder engine. The device is driven directly from the engine and consequently runs at engine speed. A detailed description of it is given in the article.

Die Eigenschaften der Fünfzylinder-Reihenverbrennungsmaschine. By H. Schrön. Published in *Der Motorwagen*, Oct. 10, 1928, p. 663. [E-1]

General agreement will be accorded the author's statements that the engine design calling for an even number of cylinders in line has become firmly established and that consequently almost no investigation has been made of the line engine with an odd number of cylinders.

This lack he attempts to make good in the present treatise on the characteristics of five-cylinder in-line engines, which is a supplement to a previous article on the same subject. In this analysis he shows torque diagrams of four, five and six-cylinder engines of similar size and compares them as to balance and quietness of running. He concludes that the five-cylinder engine has distinct advantages, especially at high speeds, and that it is well adapted to fill the gap between the territories occupied by four and six-cylinder engines.

Dyke's Aircraft-Engine Builder. By A. L. Dyke. Published by the Goodheart-Wilcox Co. 372 pp., illustrated. [E-4]

The object of the author is to familiarize the student, the mechanic and the mechanically-inclined public with the principle of operation of modern aircraft engines and their accessories.

To accomplish this purpose, the book has been divided into 16 instructions, illustrated by a wealth of diagrams and photographs. First, the author explains the principle of operation of the automotive engine and compares the aircraft with the automobile gasoline engine. Then he outlines in separate instructions the details of construction, operation and maintenance of aircraft engines of various types, including the Whirlwind and other well-known engines. Descriptions and specifications of each engine are included.

The general characteristics of the application, operation and maintenance of the following accessories are outlined: carbureters, magnetos, generators, starters, instruments and controls.

The final two divisions in the book offer general aeronautical information. The first acquaints the seeker of information with the names of aeronautical publications and aeronautical clubs, the requirements in aircraft operation, the procedure to follow in applying for airplane, pilot's or mechanic's licenses, and other data. The last contains a dictionary of aeronautical terms and symbols, reproduced from a report of the National Advisory Committee for Aeronautics.

Petrol Engines and Their Fuels. By H. R. Ricardo and O. Thornycroft. Paper presented at the Fuel Conference, World Power Conference, London, Sept. 24 to Oct. 6, 1928. [E-4]

As indicated by its title, a wide field is surveyed in the paper. The factors influencing engine efficiency are discussed under six headings: (*a*) the ratio of expansion or compression, (*b*) rate of burning, (*c*) completeness of combustion, (*d*) maximum flame temperature, (*e*) direct loss of heat to the cylinder-walls, and (*f*) loss of fuel. The authors discuss in a like manner engine power, the fac-

(*Continued on next left-hand page*)

ANOTHER MANUFACTURER IN THE AUTOMOTIVE INDUSTRY THAT USES SKF BEARINGS

Reo Motor Car Co.

YOU MAY BUY A BEARING AS A BARGAIN BUT TRY AND GET A BARGAIN OUT OF USING IT

for

Nothing is apt to cost so much as a bearing that cost so little.

SKF Puts the Right Bearing in the Right Place

For the Rigorous Demands of Bus Service the SKF Bearing and Propeller Shaft Housing

FROM coast to coast, successful motor transportation is largely dependent on the reliability of mechanical equipment. Owners of buses and trucks are vitally interested in keeping operating costs as low as possible ... consistent with the best possible service to the public.

Because of its ability to meet the rigorous requirements of bus and truck service, the SKF Self-Aligning Ball Bearing is used on the Reo Motor Bus. It is the only bearing which has the property of rolling self-alignment within itself. The best endorsement is that 42 leading manufacturers in the industry have adopted it.

SKF INDUSTRIES, INC., 40 East 34th Street, New York, N. Y. 2141

SKF

Ball and Roller Bearings

Notes and Reviews

Continued

tors which limit compression ratio, the detonation characteristics of fuels, and volatility of engine fuels. Considerable data on the effectiveness of "antiknocks" and conclusions regarding their usefulness are also given.

HIGHWAYS

Model Municipal Traffic Ordinance. National Conference on Street and Highway Safety, City of Washington, 92 pp. [F-4]

In response to requests from a number of the organizations participating in the National Conference on Street and Highway Safety that a Model Municipal Traffic Ordinance be drawn up, Secretary of Commerce Hoover, in the summer of 1927, appointed a committee to report on the subject.

The committee carried on preliminary work during the summer and fall of that year, including an analysis of the traffic ordinances of 100 American cities, together with the model ordinances existing in several States, and a study of the subject matter appropriate for an ordinance adaptable to the needs of municipalities throughout the Country. The committee then developed the results of this study into a tentative draft of a model ordinance, which was printed in May, 1928, and distributed widely among public officials and other interested individuals and groups throughout the Country for criticism and comment. At a meeting of the committee in July, 1928, the comments received were carefully considered and the Ordinance and accompanying report were revised in final form.

Besides the Model Municipal Traffic Ordinance and explanatory report, this pamphlet includes suggested drafts of three supplementary ordinances as follows: (*a*) to create an official traffic commission, (*b*) to create a division of traffic engineering, and (*c*) to control roadway and sidewalk obstructions.

MATERIALS

Ignition Points and Combustion Reactions in Diesel Engines. Parts I and II. Technical Memoranda Nos. 483 and 484. By J. Tausz and F. Schulte. Published by the National Advisory Committee for Aeronautics, City of Washington, 43 and 66 pp. respectively; illustrated. [G-1]

These Memoranda, translated by Dr. Oscar C. Bridgeman, of the Bureau of Standards, contain the results of tests made at the petroleum research laboratory of the Institute of Applied Chemistry, Technical High School, Karlsruhe, Germany, to determine the factors which influence combustion reactions. The significance of the ignition point in connection with the utility of fuel oil is discussed with special reference to the influence of increase in pressure on the ignition point.

Further work covered the effect on ignition point of the numerous chemical reactions which occur before ignition, the supersaturated state of organic compounds, possibility of the use of ignition measurements in organic chemistry, a critical review of previous work on ignition points, and combustion reactions in Diesel engines. Part I is devoted to the discussion, while Part II covers the experimental work, accompanied by sketches of the test apparatus and a presentation of the results in both tabular and graphical form.

The Fundamental Aspects of Combustion. By W. A. Bone, G. I. Finch and D. T. A. Townend. Paper presented at the World Power Conference, London, Sept. 24 to Oct. 6, 1928. [G-1]

The subject of this paper covers a wide field. The authors have chosen the aspects which seemed to be of most general interest and deal with them in four sections, name-

(*Continued on next left-hand page*)

Notes and Reviews

Continued

ly: (*a*) Thermal Considerations—heats of combustion, gaseous equilibrium, radiation from flames; (*b*) Mechanism of Combustion—combustion of carbon, carbon monoxide, hydrocarbons, and so forth; (*c*) Explosive Combustion—ignition temperatures, methods of ignition, limits of inflammability, propagation of flame, explosions in closed vessels, explosions at high pressures, knock in gasoline-air engines; and (*d*) Catalytic and Incandescent Combustion—surface combustion.

Beurteilung Von Flugmotorenkraft-Stoffen in Deutschland. By E. Rackwitz and A. Von Philippovich. Paper presented at the World Power Conference, London, Sept. 24 to Oct. 6, 1928. Abridged English translation. [G-1]

The fuel used for aviation in Germany is mainly petrol (gasoline) obtained from mineral oil. Fuel made from lignite has also been used, and petrol-benzol mixtures frequently are employed. Fuel containing additions of antiknock compounds, such as tetraethyl lead and iron carbonyl, have been tried experimentally. The authors evaluate the fuels used for aviation in Germany on the results of tests based on the following properties: compression ratio, chemical composition, specific gravity, boiling range, ignition value, behavior on cooling, corrosive properties, gumming, sulphur content, calorific value, latent heat of vaporization, and inflammability.

Thermal Expansion of Magnesium and Some of Its Alloys. Research Paper No. 29. By Peter Hidnert and W. T. Sweeney. Published by the Bureau of Standards, Department of Commerce, City of Washington, 21 pp., illustrated. [G-1]

This paper gives the results of an investigation on the linear thermal expansion of pure magnesium, magnesium-aluminum alloys, and magnesium-aluminum-manganese alloys. Magnesium, the lightest structurally used metal, and its alloys are coming into greater prominence for materials of construction where low density and strength are important factors; for example, in aircraft manufacture and for moving parts of gasoline engines.

The samples of magnesium were investigated over various temperature ranges between —183 and +500 deg. cent. (—297.4 and 932.0 deg. fahr.) and most of the alloys between room temperature and 300 deg. cent. (572 deg. fahr.). Three types of apparatus were used in this research, and a summary of available data by previous observers on the thermal expansion of magnesium and some magnesium alloys is given. The relations between the chemical composition and the coefficients of expansion of the magnesium alloys are shown in a figure, and the table in the summary gives a comparison of the average coefficients of expansion of the materials investigated.

Fatigue and Corrosion-Fatigue of Spring Material. By D. J. McAdam, Jr. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Dec. 3 to 7, 1928. [G-1]

Certain facts and relationships of fatigue of metals have been well established by numerous investigations. These are briefly mentioned and defined. A large portion of the paper is devoted to stress-cycle graphs illustrating the endurance properties of steels and alloys suitable for use in springs, as determined by rotating-cantilever tests at the Naval Engineering Experiment Station. Tables giving the chemical composition, physical properties and heat-treatment of steels and non-ferrous alloys are included, and the author discusses the influence of abrupt changes of section and of corrosion-fatigue. The latter has been the subject of several recent papers written by Mr. McAdam.

(*Continued on next left-hand page*)

Notes and Reviews

Continued

Principles of the Heat-Treatment of Steel. An outline prepared by the metallurgical staff of the Bureau of Standards. Published in *Transactions of American Society for Steel Treating*, October, 1928, p. 502. [G-1]

The large number of requests coming to the Bureau of Standards for concise information on the principles of heat-treating, and the suggestion of the Drill-Steel Committee of the American Institute of Mining and Metallurgical Engineers that an explanation of those principles be given, prompted the preparation of this outline. It deals in detail only with carbon steels and is not intended to replace more complete treatises nor to contain new information not elsewhere available, but merely to collect and present elementary principles in as simple terms as the complex nature of the factors involved in heat-treatment will permit. Definitions of the more important technical terms have been included.

The first three chapters, which deal with (*a*) factors to be considered in heat-treatment, (*b*) effect and purposes of heating, and (*c*) annealing and normalizing, appear in this issue. The article was continued in the November issue of *Transactions of the American Society for Steel Treating.*

Notes on the Relation of Design to Heat-Treatment. By Frank R. Palmer. Published in *Transactions of the American Society for Steel Treating*, October, 1928, p. 469. [G-1]

This paper sets forth the fundamental principles of design as they affect heat-treatment and, subsequently, the serviceability of finished parts.

A tool or machine part is properly designed, from the viewpoint of heat-treatment, when the entire piece can be heated and cooled at approximately the same rate, thus eliminating, insofar as possible, internal strains which develop during quenching because of wide changes of temperature. The correct shaping and the balancing of the weight of sections are discussed at some length and several interesting examples of good and poor design are presented.

Azetylen als Motorghennstoff. By R. Lutz. Published in *Der Motorwagen*, Sept. 10, 1928, p. 577. [G-1]

Two aspects, economic and technical, are dealt with in this article on acetylene as an automotive fuel. This gas was used in Norway and Switzerland during the World War because of the difficulty of importing gasoline. Utilization of a fuel obtainable within a country's own borders is not only a good emergency measure but in time of peace reduces the unfavorable trade balance, the author points out. By using acetylene instead of gasoline, Norway reduced the value of its imports by 240,000 kronen ($643,210 at present par value of the krone) during 1913, by 6,300,000 kronen ($1,688,400) during 1919 and by 10,700,000 kronen ($2, 867,600) during 1920.

Impressed by these considerations, the Chamber of Commerce of Norway instituted a research at the oil-engine laboratory of the Norwegian Technical University. The tests were made with a conventional automobile-engine adapted for acetylene by making the fewest alterations required. Comparisons with the performance of the engine when using gasoline were also made.

According to the summary given in the article, the tests proved beyond a doubt that, from the purely technical viewpoint, acetylene is eminently suited to replace gasoline as an automotive fuel. It starts the engine easily, burns without any disturbance, and is a clean-burning fuel. However, practical considerations, notably the present high cost of the gas as compared with gasoline, prevent such substitution from being made.

(Continued on next left-hand page)

Notes and Reviews

Continued

Motor Fuel and Fuel Economy. By George J. Shave. Paper presented at the fifth World Motor Transport Congress, Rome, Sept. 25 to 29, 1928. [G-4]

The author treats the subject from the practical point of view and expresses the hope that this survey of conditions and limitations met in providing fuel of suitable types to serve the needs of the several different classes of motor transport now operating in Great Britain may assist in guiding the research and production of fuels for the internal-combustion engine. An account of the present use of petroleum substitutes in England and the status of research in this field are included with a summary of desirable characteristics as determined by the best performance.

Carboloy and Tungsten-Carbide Tools. By Samuel L. Hoyt. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Dec. 3 to 7, 1928. [G-4]

Considerable interest has been shown in the last few years in the new tool materials which have tungsten carbide as a base. The most promising field for the use of these tools is in machining materials which are so abrasive that ordinary tools are speedily worn away or lose their cutting edge but which do not exert great pressure on the tool. The author points out that the economic value of Carboloy (a trade name adopted by the General Electric Co. for such material) is so great in many instances that it at once justifies its use. In some others this will not be so marked and in still other cases its use will be less economical or not at all suitable. Among the latter applications may be mentioned finishing cuts on iron and steel, hogging cuts on steel, or, in general, cuts with heavy feeds and cuts which impose heavy pressures on the tool.

Mechanical Applications of Chromium-Plating. By W. Blum. Paper presented at the annual meeting of the American Society of Mechanical Engineers, New York City, Dec. 3 to 7, 1928. [G-4]

After giving particulars regarding the physical properties of chromium such as hardness, thermal expansivity, density, melting point, electrical conductivity, and adherence, the author discusses the uses to which chromium-plating, by reason of its wear-resisting qualities, has been more or less successfully put; namely, its application to gages and other measuring devices; to drawing, forming, stamping, and molding dies; to rolls for forming and to tools for cutting metal; and to bearing surfaces in machinery. He shows how, in addition to savings arising from the longer life of chromium-plated tools and parts, savings much greater in amount result from reducing the number of times that machines must be stopped for replacement of tools.

Lectures on Steel and Its Treatment. By John F. Keller. Evangelical Press, Cleveland, Ohio, 267 pp., illustrated. [G-5]

The author, in stating the purpose of his book, expresses the desire to assist men in the metal-trade industries to a better understanding of the basic principles that underlie the various processes of producing iron and steel tools and machinery. The book is written for the man without technical training and bridges for him the gap between a slight understanding of the fundamentals of steel treating and the stage of knowledge in which he can profitably read more technical literature on the subject.

Professor Keller is particularly well fitted to write in this vein since he has come up from a blacksmith to an assistant professorship in Purdue University, where, as part

(Continued on third left-hand page)